

St. Joseph River Watershed Indiana TMDLs

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Abbreviations and Acronyms

AFG	allocation for future growth
ALU	aquatic life use
ARS	Agricultural Research Service (U.S. Department of Agriculture)
CSO	combined sewer overflow
BHSJ	Branch-Hillsdale-St. Joseph Community Health Agency (Michigan)
CAFO	concentrated animal feeding operation
CFO	confined feeding operation
CSS	combined sewer system
CWA	Clean Water Act
EBSJR	East Branch St. Joseph River
EFWBSJR	East Fork West Branch St. Joseph River
FDC	flow duration curve
HSTS	home sewage treatment system
HU	hydrologic unit
HUC	hydrologic unit code
IBC	impaired biotic communities
IDEM	Indiana Department of Environmental Management
Lake Erie LaMP	Lake Erie Lake Management Plan
LA	load allocation
LDC	load duration curve
Michigan DEQ	Michigan Department of Environmental Quality
MOS	margin of safety
NBEC	North Branch Eagle Creek
NPS	nonpoint source
NRCS	Natural Resources Conservation Service (U.S. Department of Agriculture)
ODH	Ohio Department of Health
ODNR	Ohio Department of Natural Resources
Ohio EPA	Ohio Environmental Protection Agency
OIALW	other indigenous aquatic life and wildlife
OWTS	on-site wastewater treatment system
RM	river mile
RU	recreation use (in Ohio and Michigan) or recreational use (in Indiana)
SJR	St. Joseph River
SJRW	St. Joseph River Watershed
SJRWI	St. Joseph River Watershed Initiative
SRF	state revolving fund
SSO	sanitary sewer overflow
STP	sewage treatment plant
SWAT	Soil and Water Assessment Tool
SWCD	soil and water conservation district
USDA	United States Department of Agriculture)
U.S. EPA	United States Environmental Protection Agency
U.S. FWS	United States Fish and Wildlife Service (U.S. Department of the Interior)
USGS	United States Geological Survey (U.S. Department of the Interior)
WBSJR	West Branch St. Joseph River
WFWBSJR	West Fork West Branch St. Joseph River
WLA	wasteload allocation
WMP	watershed management plan
WQS	water quality standards

WWH	warmwater habitat
WWSL	wastewater stabilization lagoon
WWTP	wastewater treatment plant
WY	water year

Units of Measure

c/d	counts per day
counts/100 mL	counts per 100 milliliters
gpd	gallons per day
mgd	million gallons per day
mg/L	milligrams per liter

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- Indiana Department of Environmental Management (IDEM)
- Michigan Department of Environmental Quality (Michigan DEQ)
- Ohio Environmental Protection Agency (Ohio EPA)
- Ohio Department of Natural Resources
- St. Joseph River Watershed Initiative
- Tetra Tech, Inc.
- U.S. EPA, Regions 5

Executive Summary

The St. Joseph River (SJR) watershed is in northwestern Ohio, south central Michigan, and northeast Indiana and drains to the Maumee River, encompassing approximately 1,085 square miles. In Ohio and Indiana, the SJR and its tributaries are impaired for their designated recreation uses by *Escherichia coli* (*E. coli*); are impaired for their aquatic life uses (ALU) by nutrients, sediment, and non-pollutants (e.g., direct habitat alteration); and are impaired for human health due to the presence of polychlorinated biphenyls in fish tissue. ALU impairments from non-pollutants and human health impairments are not addressed herein.

The Clean Water Act and U.S. Environmental Protection Agency (EPA) regulations require that states develop Total Maximum Daily Loads (TMDLs) for waters that the states list as impaired on their section 303(d) lists. The TMDL and water quality restoration planning process involves several steps including watershed characterization, target identification, source assessment, and allocation of loads.

U.S. EPA's original goals for the St. Joseph River Watershed (SJRW) TMDL project were to assist the Ohio Environmental Protect Agency (Ohio EPA), the Indiana Department of Environmental Management (IDEM), and the Michigan Department of Environment Quality (MDEQ) in the development of multi-state TMDLs for impaired waterbodies of the SJRW. These goals were modified due to an Ohio Supreme Court ruling in March 2015. In *Fairfield County Board of Commissioners v. Nally* (March 2015), the Ohio Supreme Court determined that a TMDL is a rule and that a TMDL in Ohio must be promulgated before it can be submitted to U.S. EPA for approval. This ruling has affected Ohio EPA's ability to finalize and submit TMDLs to U.S. EPA given that Ohio EPA currently does not have TMDL promulgation processes in place.

The implications and timing of this ruling have impacted the SJRW TMDL project. Originally, U.S. EPA planned to develop a single TMDL report for the entire watershed, addressing impaired segments in Indiana and impaired watershed assessment units (WAUs) in Ohio. But due to the Ohio Supreme Court ruling, U.S. EPA has revised its approach to present the TMDLs in two different reports: one with the TMDLs for impaired segments in the SJRW within the boundaries of the state of Indiana, and a second report with the TMDLs for impaired WAUs in the SJRW within the boundaries of the state of Ohio. The TMDLs in the SJRW for Indiana are presented in this report. TMDLs for the impaired waters in the SJRW in Ohio will be presented in a report at a later date.

This document presents the results of a TMDL study for the Indiana-portion of the SJRW. The watershed characterization and source assessment are presented for the entire SJRW and rely, in part, on valuable background information provided in watershed improvement plans, state agency issued water quality reports, and many additional existing studies. The linkage analyses, TMDLs, allocations, and implementation plan framework are specific to the Indiana-portion of the SJRW.

TMDLs in Indiana were developed using a load duration curve (LDC) approach using flow simulated from a watershed-scale model. TP and TSS targets in Indiana were set to 0.30 milligrams per liter (mg/L) for TP and 30 mg/L for TSS, while *E. coli* targets were selected from Indiana's recreational use criteria (125 counts per 100 milliliters).

The following TMDLs were developed in Indiana (Notes

TMDL = total maximum daily load; TP = total phosphorus; TSS = total suspended solids.

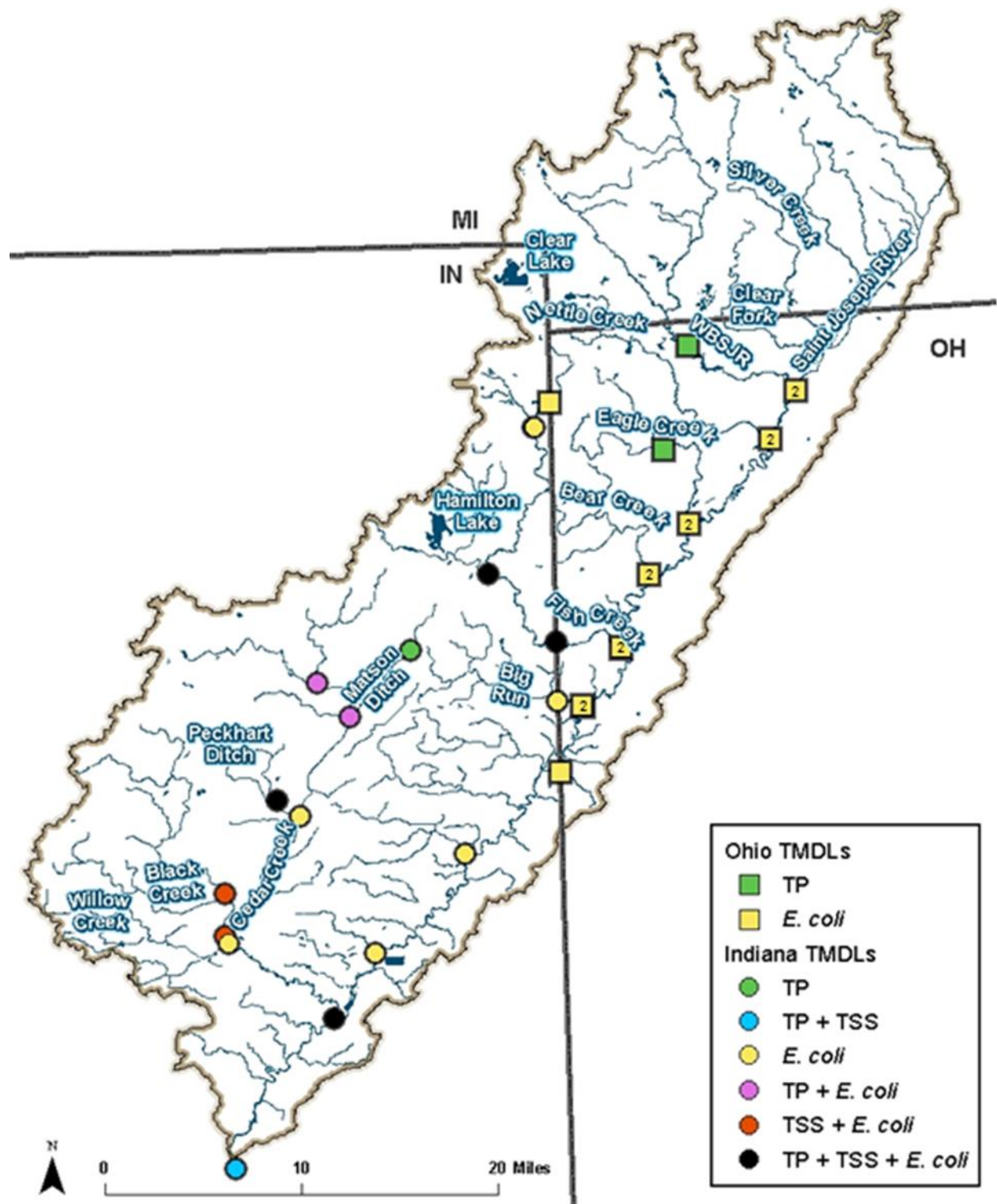
Ohio *E. coli* TMDL symbols along the SJR overlap Ohio *E. coli* TMDL symbols at the mouths of tributaries to the SJR.

Figure 1):

- *E. coli* TMDLs were developed at 17 sites in the watershed to address 60 impaired segments
- TSS TMDLs were developed at 7 sites to address 7 segments with impaired biotic communities (IBC)
- TP TMDLs were developed at 8 sites to address 7 segments impaired by nutrients, 18 segments with IBCs, and 2 segments impaired by low dissolved oxygen

Reductions of current loads are necessary to achieve the loads specified within the TMDLs. When reductions were necessary, the reductions in the SJR mainstem in Indiana ranged from 1 to 90 percent for *E. coli*; 4 to 66 percent for TP; and 14 to 95 percent for TSS. Reductions for the tributaries of the SJR in Indiana ranged from 14 percent to >99 percent for *E. coli*; 3 to 84 percent for TP; and 17 to 94 percent for TSS.

Implementation of the TMDLs will be accomplished through the National Pollutant Discharge Elimination System (NPDES) program for permitted point sources and through application of best management practices (BMPs) to address agricultural and urban runoff.



Notes

TMDL = total maximum daily load; TP = total phosphorus; TSS = total suspended solids.

Ohio *E. coli* TMDL symbols along the SJRW overlap Ohio *E. coli* TMDL symbols at the mouths of tributaries to the SJRW.

Figure 1. TMDLs in the SJRW.

1 Introduction

The St. Joseph River watershed (SJRW) is in northwestern Ohio, south central Michigan, and northeast Indiana. The watershed encompasses approximately 1,085 square miles and drains to the Maumee River. The SJRW consists of one 8-digit hydrologic unit (hydrologic unit code [HUC] 04100003) that is further subdivided into eight 10-digit hydrologic units (HUs) and 45 12-digit HUs (Figure 2 and Table A-1 in Appendix A).

In 2005, the Michigan Department of Environmental Quality (Michigan DEQ) conducted surveys of the East Branch St. Joseph River (EBSJR) and West Branch of the St. Joseph River (WBSJR). Macroinvertebrate community health was typically good to excellent and therefore met the other indigenous aquatic life and wildlife (OIALW) designated use. Numeric chemical criteria were met in most locations, although mercury and zinc exceeded criteria in a few samples and nutrients were sometimes detected at levels above expected ranges. No impairments are contained in Michigan's draft 2016 Integrated Report.

In 2013, the Ohio Environmental Protection Agency (Ohio EPA) evaluated the biological health and water quality of its portion of the SJRW (Ohio EPA 2015a). The results indicated that the watershed assessment units (WAUs; equivalent to 12-digit hydrologic units) that are composed of the tributaries to the St. Joseph River (SJR) were impaired for their designated aquatic life uses (ALUs) and recreation uses (RUs). Ohio EPA also found the SJR mainstem to be impaired for its recreation use (RU). The impaired WAUs and mainstem are listed in Ohio's draft 2016 Integrated Report.

Fixed water quality monitoring sites are sampled for nutrients and total suspended solids (TSS) a few times per year in Indiana, including most recently in 2014. Indiana Department of Environmental Management (IDEM) listed six segments of Cedar Creek and one segment of Dosch Ditch for nutrient impairments, 18 segments for impaired biotic communities (IBC), and one segment each on Fish Creek and Peckhart Ditch for dissolved oxygen in Indiana's draft Clean Water Act (CWA) 303(d) list (IDEM 2014c). IDEM also found two segments of the mainstem SJR and 57 segments in the SJRW to be impaired for RUs. Eight segments of the Cedarville Reservoir are also impaired for their RUs, but IDEM will address the Cedarville Reservoir impairments at a later date. Segments of the SJR, Cedar Creek, and Davis Ditch are impaired by polychlorinated biphenyls but these human health use impairments were not addressed in this TMDL project.

The CWA and U.S. Environmental Protection Agency (U.S. EPA) regulations require that states develop TMDLs for waters on the section 303(d) lists. The TMDL and water quality restoration planning process involves several steps including watershed characterization, target identification, source assessment, allocation of loads, and prioritization of implementation activities. TMDL targets and allocations are derived from the water quality standards (designated uses, narrative and numeric criteria). The TMDL allocations are separated into wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources.

The TMDL project area for this study is defined as the entire 8-digit HU, including the mainstem and tributary subwatersheds. While Lake Erie is not within the project area, TMDL implementation within the project area is anticipated to help improve water quality in the Maumee River and eventually in Lake Erie's Western Basin. TMDLs for aquatic life and recreation uses were developed. The overall goals and objectives in developing the TMDLs for this project area are as follows:

- Assess the water quality within the project area and identify key issues associated with the impairments and potential pollutant sources.

- Use the available research and data to identify the water quality conditions that will result in all streams fully supporting their designated uses.
- Prepare a final TMDL report for the Indiana portion of the SJRW that meets the requirements of the CWA and provides information to the stakeholders that can be used to facilitate implementation activities and improve water quality.
- Provide a framework implementation plan to address the necessary load reductions that is consistent with the existing watershed management plans.

The results of the TMDL process are documented in this report.

Water quality data and information that supported TMDL development were provided the St. Joseph River Watershed Initiative (SJRWI). The SJRWI (<http://www.sjrwi.org/>) is a non-profit organization that seeks to improve water quality in the SJRW. The organization actively monitors water quality the SJR and its tributaries. SJRWI has worked with local government agencies to develop watershed management plans to address water quality impairment throughout the SJRW.

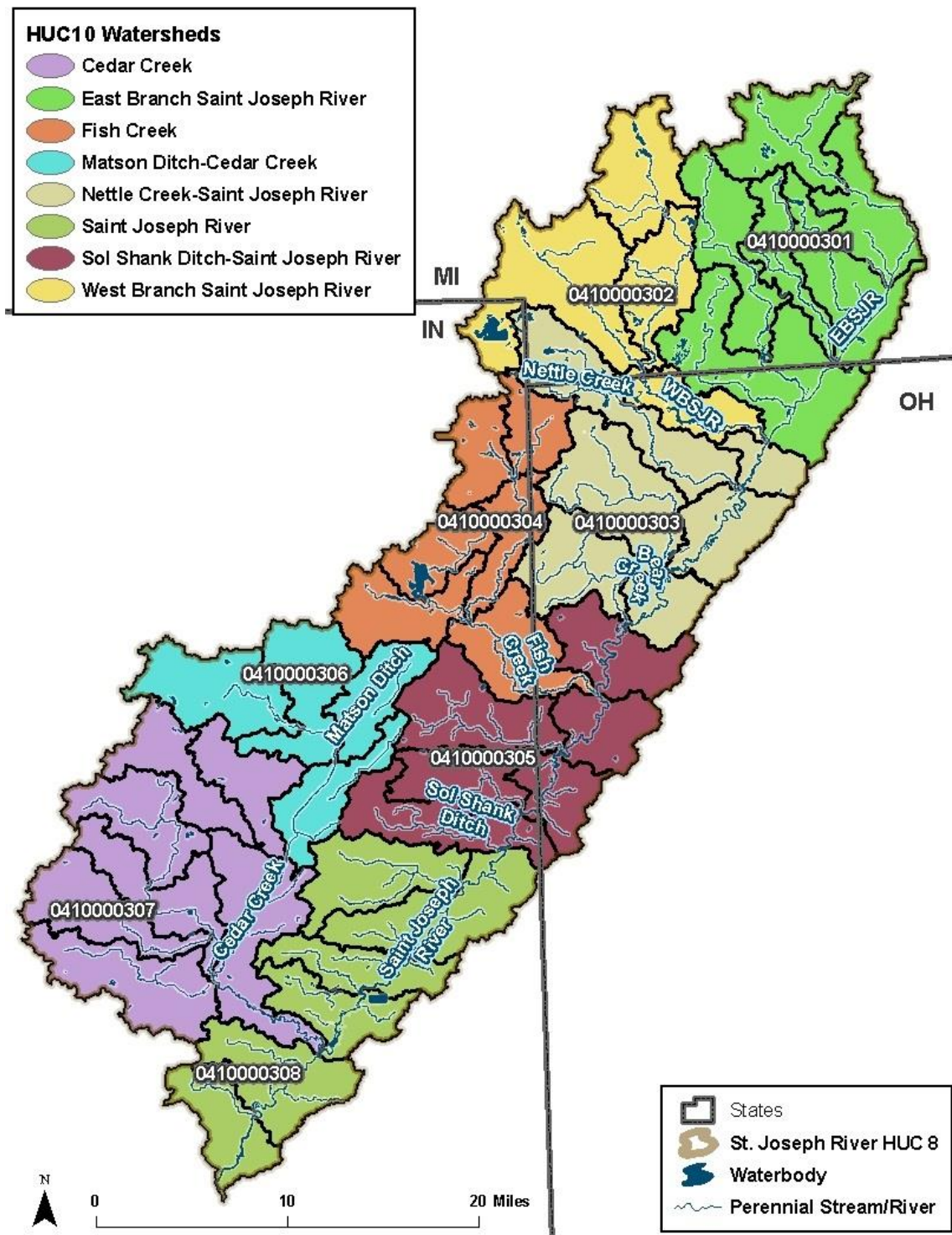


Figure 2. 10-digit hydrologic units in the SJRW.

2 Water Quality Standards and Impairments

This section summarizes the applicable water quality standards (WQS) for waters in the TMDL project area (Table 1) and provides information on the waterbody impairments. The WQS for the states are promulgated in each state's administrative codes:

- Michigan Administrative Rules, *Part 4. Water Quality Standards* (R 323.1041 - 323.1117)¹
- Ohio Administrative Code (OAC) chapter 3745-1²
- Indiana Administrative Code (IAC) chapter 327 article 2³

Table 1. State water quality standards

Component	Description
Designated Use	Designated use reflects how the water could be used by humans and how well it supports a biological community. Every water has a designated use or uses; however, not all uses apply to all waters (i.e., they are waterbody specific).
Numeric Criteria	Chemical criteria represent the concentration of a pollutant that can be in the water and still protect the designated uses of the waterbody. Biological criteria indicate the health of the in-stream biological community by using indices that measure aquatic species community health.
Narrative Criteria	These are the general water quality criteria that apply to all surface waters. These criteria state that all waters must be free from sludge; floating debris; oil and scum; color- and odor-producing materials; substances that are harmful to human, animal or aquatic life; and nutrients in concentrations that can cause algal blooms.
Antidegradation Policy	This policy establishes situations under which state agencies may allow new or increased discharges of pollutants, and requires those seeking to discharge additional pollutants to demonstrate an important social or economic need.

TMDLs presented in this report were only developed to address impairments in Indiana; Michigan and Ohio WQS are also presented because waters in those states drain to Indiana. U.S. EPA draft guidance on multijurisdictional TMDLs (U.S. EPA 2012b), explains that *the central goal of the CWA and EPA's implementing regulations is to ensure that downstream States/Tribes are not subjected to pollutant loads from upstream or adjacent jurisdictions that cause or contribute to the impairment of downstream waters*. U.S. EPA encourages upstream or adjacent states to calculate loading contributions that may be impacting downstream impaired waters. These calculations should be represented as separate loads within TMDLs addressing downstream impaired waters (e.g., refer to Table H-4 in Appendix H for an *Ohio upstream allocation*).

2.1 Designated Uses

Beneficial use designations define the existing and potential uses of a waterbody. The designated uses consider human health, recreation, aquatic life, water supplies (agricultural, drinking, and industrial), and navigation (Table 2). In Michigan, designated uses for tributaries to the SJR are either, coldwater fisheries, warmwater fisheries, and OIALW. In Ohio, designated uses for the SJRW were promulgated into *OAC-3745-1-11*, which contains designated uses in the Maumee River watershed; most waterbodies are designated as warmwater habitat (WWH) and primary contact recreation (PCR) (Table A-2 in

¹ R 323.1041 - 323.1117 is available at http://www.michigan.gov/documents/deq/wb-swas-rules-part4_254149_7.pdf (accessed October 31, 2014)

² OAC-3745-1 is available at http://epa.ohio.gov/dsw/rules/3745_1.aspx (accessed October 31, 2014)

³ 327 IAC 2 is available at <http://www.in.gov/legislative/iac/T03270/A00020.PDF> (accessed October 31, 2014).

Appendix A). Indiana waters are designated for aquatic life use and, in Indiana, all waters are designated for full body contact recreation use, unless specifically designated otherwise.

Table 2. Designated uses in Indiana, Michigan, and Ohio

Indiana	Michigan	Ohio
All designated uses per state		
<ul style="list-style-type: none"> ▪ Agricultural use ▪ Aquatic life ▪ Exceptional use ▪ Fish consumption ▪ Full body contact [recreation] ▪ Industrial water supply ▪ Limited use ▪ Public water supply 	<ul style="list-style-type: none"> ▪ Agriculture ▪ Coldwater fishery ▪ Fish consumption ▪ Full body contact recreation ▪ Industrial water supply ▪ Navigation ▪ Other indigenous aquatic life and wildlife ▪ Partial body contact recreation ▪ Warmwater fishery 	<ul style="list-style-type: none"> ▪ Agricultural water supply ▪ Aquatic life ^a ▪ Human health (fish tissue) ▪ Industrial water supply ▪ Public water supply ▪ Recreation ^b
Designated uses addressed by TMDLs		
<ul style="list-style-type: none"> ▪ Aquatic life ▪ Full body contact [recreation] 	(no TMDLs were developed in Michigan)	<ul style="list-style-type: none"> ▪ Aquatic life ▪ Recreation

Sources: Appendix A of Indiana's draft 2014 Integrated Report (IDEM 2014c), Appendix B2 of Michigan's 2014 Integrated Report (Michigan DEQ 2014b), and OAC-3745-1-07.

Notes

a. Ohio's aquatic life use is delineated into coldwater habitat, exceptional warmwater habitat, limited resources water, modified warmwater habitat (with three sub-delineations), seasonal salmonid habitat, and warmwater habitat.

b. Ohio's recreation use is delineated into bathing waters, primary contact, and secondary contact.

2.2 Numeric Criteria

Numeric criteria are typically based on concentrations of pollutants and degree of aquatic life toxicity allowable in a waterbody without adversely affecting its beneficial uses. They consist of biological criteria, chemical criteria, and whole effluent toxicity levels. In the case of biological criteria, the numeric criteria are the biological community index scores that represent conditions where the designated use is met. The criteria applicable to the project area that are pertinent to the TMDL project are presented in the following sections.

2.2.1 Biological Criteria

Biological criteria⁴ (also referred to as biocriteria) “are narrative descriptions or numerical values of the structure and function of aquatic communities in a waterbody necessary to protect the designated aquatic life use, implement in, or through water quality standards” (Flotemersch et al. 2006, p. G-2). Biological criteria are typically set using biological indices⁵; for example, the Index of Biological Integrity (IBI) measures fish community health.

⁴ The scientific definition varies from the regulatory definition, which is that biological criteria “are quantified values representing the biological condition of a waterbody as measured by structure and function of the aquatic communities typically at reference conditions” (Flotemersch et al. 2006, p. G-2).

⁵ Biological indices are “a set of metrics collected into a single score calibrated to reference conditions and used as a measure of biological condition” (Flotemersch et al. 2006, p. G-2).

2.2.1.1 Ohio

The biological criteria in Ohio are numeric and vary by ALU designation and level III ecoregion⁶. ALU designations in Ohio include coldwater habitat (CWH), exceptional warmwater habitat, seasonal salmonid habitat, warmwater habitat (WWH), modified warmwater habitat (MWH), and limited resource waters (LRW). The ability of a waterbody to meet its ALU designation is based primarily on the scores it receives on three community indices, as applicable: the IBI, the Modified Index of well-being (MIwb), and the Invertebrate Community Index (ICI). The IBI and MIwb are based on the composition and health of the fish community, and the ICI is based on the composition of the macroinvertebrate community.

2.2.1.2 Indiana

While IDEM uses biological indices for use attainment assessment, biological criteria have not been promulgated into the WQS numeric criteria rules. The IBI and macroinvertebrate Index of Biotic Integrity (mIBI) are used for ALU support of rivers and streams in Indiana⁷. However, nutrients (total phosphorus [TP], nitrate plus nitrite [NN]), dissolved oxygen, pH, and algal condition are evaluated with the IBI and mIBI to assess ALU attainment⁸.

2.2.2 Chemical Criteria

Each state uses *Escherichia coli* (*E. coli*) to assess their designated RUs; *E. coli* is an indicator species for pathogens that are harmful to human health. The numeric criteria, designated RUs, and recreation seasons vary between the states (Table 3).

⁶ North America is delineated into four levels of nested ecoregions. Level I ecoregions are the largest and allow for coarse, continental analyses while level IV ecoregions are the smallest and allow for fine, localized analyses (Commission for Environmental Cooperation 1997). The SJRW is within the *Eastern Temperate Forest* level I ecoregion (#8); within the *Mixed Wood Plains* (#8.1) and *Central USA Plains* (#8.2) level II ecoregions; within the *South Michigan / Indiana Drift Plane* (#8.1.6 and #56) and *Eastern Corn Belt Plains* (#8.2.4 and #55) level III ecoregions; and within *Clayey High Lime Till Plains* (#55a), *Northern Indiana Lake Country* (#56a), *Battle Creek/Elkhart Outwash Plain* (#56b), *Interlobate Dead Ice Moraines* (#56h) level IV ecoregions.

⁷ To be fully supporting the ALU, the IBI and mIBI must be greater than or equal to a score of 36.

⁸ Total phosphorus (TP), nitrate plus nitrite (NN), dissolved oxygen, pH, and algal condition are evaluated from at least three sampling events; if three or more of the five parameters exceed criteria, then the ALU is not attained. Qualitative Habitat Evaluation Index data are not directly used for determining ALU support but are used to help assess the cause(s) of impairment to aquatic community health.

Table 3. Numeric criteria for the protection of RU

Component	Indiana	Michigan ^a	Ohio ^b
Recreation season	Apr - Oct	May - Oct	May - Oct
Indicator	<i>E. coli</i>	<i>E. coli</i>	<i>E. coli</i>
Maximum criteria (count per 100 mL)	Single sample	Daily (geometric mean of sample event) ^c	Single sample
	235 ^f	TBCR: 300 PBCR: 1,000 ^d	<u>Bathing water</u> : 410 <u>PCR</u> : 410 <u>SCR</u> : 1,030
Geometric mean criteria (count per 100 mL)	5 equally spaced samples over 30-days	5 or more individual sample events over a 30-day period	90-day
	<u>FBC</u> : 125	<u>TBCR</u> : 130	<u>Bathing water</u> : 126 ^e <u>PCR</u> : 126 ^e <u>SCR</u> : 1,030
Promulgated rules	327 IAC 2-1.5-8(e)	R 323.1062 R 323.1100	OAC 3745-1-37, Table 37-2

Notes

FBC = full body contact; IAC = Indiana Administrative Code; mL = milliliter; MPN = most probable number; OAC = Ohio Administrative Code; PBCR = partial body contact recreation; PCR = primary contact recreation; SCR = secondary contact recreation; TBCR = total body contact recreation.

a. Michigan defines a sample event as 3 or more individual samples at representative locations within a defined sample area.

b. Ohio criteria apply inside and outside of mixing zones. Single sample criteria may not be exceeded in more than 10 percent of samples.

c. Compliance is based upon the geometric mean of the individual samples collected during a *sample event*, as defined in footnote 'a' above

d. Michigan's partial body contact recreation criterion is applicable year round.

e. The St. Joseph River is designated PCR and J. Lattener Ditch is designated SCR; all other waterbodies are designated PCR. Any discharger within 5 miles of a more stringent downstream designated use must discharge to protect that downstream use.

f. If five equally spaced samples were not collected over a 30-day period, then the single sample maximum criteria may be used to determine attainment. Additionally, the single sample maximum criteria is used for making beach notification and closure decisions, according to 327 IAC 2-1.6(d).

2.3 Narrative Criteria and Guidance

Narrative criteria are the general water quality criteria that apply to all surface waters. Those criteria, promulgated in 327 IAC 2-1-5-8(b)(1)(A) through (D) for the Great Lakes system, R 323.1050, and OAC-3745-1-04, generally state that all waters must be free from sludge, floating debris, foam oil and scum, color- and odor-producing materials, substances that are harmful to human, animal or aquatic life, and nutrients in concentrations that can cause nuisance aquatic plant growth or algal blooms.

2.3.1 Nutrients

Indiana, Michigan, and Ohio do not have numeric criteria for aquatic life use impairments caused by nutrients or sediment. Each state uses different nutrient and sediment targets based upon different methodologies.

2.3.1.1 Michigan

Michigan DEQ uses a site-specific approach to identify nutrient TMDL targets based on Michigan's narrative criteria. This methodology includes an evaluation of relevant data that describe the relationship between designated uses and nutrients. Michigan DEQ implements site-specific targets through NPDES permits and TMDLs.

2.3.1.2 Ohio

In Ohio, TMDL targets are selected on the basis of evaluating reference stream data published in a technical report titled *Association between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and*

Streams (Ohio EPA 1999; referred to throughout as the *Associations* document). The document identifies ranges of concentrations for NN and TP on the basis of observed concentrations at all sampled ecoregional reference sites. Those reference stream concentrations were used as TMDL targets and are shown in Table 4. While nutrient targets are not codified in Ohio's water quality standards, Ohio EPA's methodology is very rigorous and the linkage of the targets to the health of the aquatic community is well established in the *Associations* document. Targets from the *Associations* documents have been used in numerous recent TMDLs approved by U.S. EPA⁹.

Table 4. Ohio's statewide-suggested TP targets (mg/L) for the protection of aquatic life

Stream class	Stream size (square miles)	Beneficial use		
		EWH	WWH	MWH
Headwaters	< 20	0.05	0.08	0.34
Wading	20 - 200	0.05	0.10	0.28
Small river	200 - 1,000	0.10	0.17	0.25
Large river	> 1,000	0.15 ^a	0.30	0.32

Source: Ohio EPA 1999

Notes:

EWH = exceptional warmwater habitat; mg/L = milligrams per liter; MWH = modified warmwater habitat; WWH = warmwater habitat. Statewide total phosphorus recommendations were generated by Ohio EPA (1999) with ANOVA analyses of statewide pooled data.

a. Assumes a nitrogen:phosphorus ratio that is greater than or equal to 10:1.

2.3.1.3 Indiana

In Indiana, the nutrient TMDL target is typically 0.30 milligrams per liter (mg/L) TP. IDEM uses the TP target values, along with pH, dissolved oxygen, and algal information, to determine ALU support for rivers and streams. Typically, if two or more of the targets are exceeded, then the ALU is impaired and nutrients are considered a cause of impairment.

Indiana TP TMDLs in the SJRW were set to a target concentration of 0.30 mg/L. This target was used for TP TMDLs that address segments listed for nutrients and for segments listed for IBC when any TP concentrations in such a segment exceed the target of 0.30 mg/L.

2.3.2 Habitat

IDEM and Ohio use the Qualitative Habitat Evaluation Index (QHEI) to evaluate ALU attainment and identify the potential causes and sources of ALU impairment. The QHEI is a quantitative expression of a qualitative, visual assessment of habitat in free-flowing streams and was developed by Ohio EPA to assess available habitat for fish communities (Rankin 1989, 1995). The QHEI is a composite score of six physical habitat categories:

- Substrate
- In-stream cover
- Channel morphology
- Riparian zone and bank erosion
- Pool/glide and riffle/run quality
- Gradient

⁹ The following are examples of recent Ohio TMDLs that used targets from the *Associations* document (Ohio EPA 1999) and were approved by U.S. EPA Region 5: *Maumee River (Lower) Tributaries and Lake Erie Tributaries TMDL Report* (Ohio EPA 2012b), *Total Maximum Daily Loads for the Grand River (Lower) Watershed* (Ohio EPA 2012a), *Total Maximum Daily Loads for the Sandusky River (lower) and Bay Tributaries Watershed* (Ohio EPA 2014b), *Total Maximum Daily Loads for the White Oak Creek Watershed* (Ohio EPA 2009b), *Total Maximum Daily Loads for the Swan Creek Watershed* (Ohio EPA 2009a).

Each of those categories is subdivided into specific attributes that are assigned a point value reflective of the attribute's effect on the aquatic life. Highest scores are assigned to the attributes correlated to streams with high biological diversity and integrity and lower scores are progressively assigned to less desirable habitat features. A QHEI evaluation form¹⁰ is used by a trained evaluator while at the sampling location. Each of the components is evaluated on-site, recorded on the form, the score totaled, and the data later analyzed in an electronic database.

The QHEI is a macro-scale approach that measures the emergent properties of habitat (sinuosity, pool/riffle development) rather than the individual factors that influence the properties (current velocity, depth, substrate size). The QHEI is used to evaluate the characteristics of a short stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites could have poorer physical habitat because of a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. However, QHEI evaluations are segment specific and do not give a strong indication of the quality of the habitat in other stream segments.

QHEI scores can range from 12 to 100. Ohio EPA (2006) has determined appropriate QHEI target scores through statistical analysis of Ohio's statewide database of paired QHEI and IBI scores. Simple linear and exponential regressions and frequency analyses of combined and individual components of QHEI metrics in relation to the IBI were examined. The regressions indicate that the QHEI is significantly correlated with the IBI. QHEI scores of more than 75 generally indicate excellent stream habitat, scores between 60 and 75 indicate good habitat quality, and scores of less than 45 demonstrate habitat that is not conducive to WWH. Scores between 45 and 60 need separate evaluation by trained field staff to determine the stream's ALU potential.

In Indiana, the QHEI scores are used with IBC listings to determine if habitat is the primary stressor affecting the IBC or if multiple stressors are causing the IBC. IDEM considers QHEI scores less than 51 to indicate poor habitat.

2.3.3 Sediment

Using TSS as an indicator of sediment in the water column is fairly common and has been used in numerous TMDL reports; however, TSS concentrations can be an underestimation of sediment loads because they account only for particles small enough to remain suspended in the water column. Larger particles, such as sand and coarser particles, that could have the most influence on aquatic life and stream substrates are often not included in TSS concentrations because they usually settle out of the water column. Several of the QHEI metrics are also useful for assessing sedimentation and siltation.

2.3.3.1 Michigan

Michigan DEQ uses a site-specific approach to identify TSS TMDL targets using Michigan's narrative WQSs. This methodology includes an evaluation of relevant data that describe the relationship between designated uses and sedimentation/siltation. Michigan DEQ implements site-specific targets through NPDES permits and TMDLs.

2.3.3.2 Ohio

In Ohio, TSS TMDL targets are typically selected from the *Associations* document (Ohio EPA 1999), as discussed in Section 2.3.1.2. The document identifies ranges of concentrations TSS on the basis of observed concentrations at all sampled ecoregional reference sites. One of the methods that U.S. EPA recommends is basing nutrient criteria on the 75th percentile of the frequency distribution of reference streams (U.S. EPA 2000).

¹⁰ The evaluation form is available at <http://www.epa.ohio.gov/portals/35/documents/QHEIFieldSheet061606.pdf>.

No Ohio WAU is impaired by sedimentation/siltation; thus, no TSS TMDLs were developed. TSS targets based upon the *Associations* document (Ohio EPA 1999) are presented in this report for reference since Ohio streams drain to some Indiana impairments that were addressed through TSS TMDLs.

2.3.3.3 Indiana

In Indiana, sediment TMDL targets are typically 30 mg/L TSS. TSS is a surrogate pollutant used to address impairments caused by sedimentation and siltation, which can include IBC listings.

Indiana TSS TMDLs in the SJRW were set to a target concentration of 30 mg/L. This target was used for TSS TMDLs that address segments listed for IBC when any TSS concentrations in such a segment exceed the target of 30 mg/L.

2.4 Impairments

Portions of the mainstem of the SJR and certain tributaries within the SJRW are not meeting WQS and targets. The SJR is not meeting its designated ALU in Indiana and its designated RUs in Ohio and Indiana; its tributaries are not meeting the designated ALUs and RUs in Ohio and Indiana. The scope of this project is limited to anthropogenic impairments to designated ALUs and RUs; impairments due to polychlorinated biphenyls in fish tissue in Indiana were not addressed in this TMDL document. IDEM will revisit the PCB impairments in the SJRW at a later date. No other designated uses were identified as impaired by the state agencies.

2.4.1 Aquatic Life Uses

Tributaries in the SJRW (HUC 04100003) are not attaining their designated ALUs due to excessive nutrients and sediment.

2.4.1.1 Michigan

According to the Michigan 2014 Integrated Report (Michigan DEQ 2014b), the ALU assessments in the SJRW were either fully supporting WQS or were not assessed. Therefore, TMDLs which would have addressed ALU impairments will not be developed in Michigan for the SJRW TMDL effort.

2.4.1.2 Ohio

Ohio lists impairments by watershed assessment unit (WAU)¹¹. ALU impairments evaluated in this TMDL project are based upon 2013 and 2014 monitoring data. These samples were not evaluated and impairments were not determined before the publication of Ohio's CWA 303(d) list in its 2014 Integrated Report (Ohio EPA 2014a). The 2013 and 2014 monitoring data will be used to develop Ohio's 2016 303(d) list¹². The impairments are summarized in Figure 3 and presented in Table A-3 in Appendix A.

TMDLs developed for Ohio will be published in a future TMDL document. Nutrient TMDLs will be developed for the West Branch St. Joseph River (HUC 04100003 02 04) and Eagle Creek (*03 03). TMDLs will not be developed for Clear Fork (*04 06; natural conditions), Eagle Creek (04100003 03 03; direct habitat alterations), or Nettle Creek (*03 01; direct habitat alterations).

¹¹ Ohio EPA samples representative monitoring sites in each WAU. Ohio EPA's monitoring sites are presented in Table A-8 and Table A-9 in Appendix A.

¹² Angela Defenbaugh & Cathy Alexander, Ohio EPA, personal communication (via electronic mail), December 17, 2014.

2.4.1.3 *Indiana*

Indiana lists impairments by stream segment¹³ and the ALU impairments are presented in Indiana's draft 2014 303(d) list (IDEM 2014c). The impairments are summarized in Figure 4 and presented in Table A-5 in Appendix A. Seven segments across three 12-digit HUs are impaired by nutrients and TP TMDLs were developed. Eighteen segments across eleven 12-digit HUs are listed for IBC. Six TP TMDLs were developed to address the IBC-impaired segments with elevated levels of TP and seven TSS TMDLs were developed to address the IBC-impaired segments with elevated levels of TSS¹⁴. Two TP TMDLs may also help to address dissolved oxygen impairments.

¹³ IDEM monitoring sites that were used to assess attainment are presented in Table A-10 and Table A-11 in Appendix A.

¹⁴ IDEM did not identify causes or sources of impairment for segments listed for IBC (IDEM 2014c). Only those impaired segments that also have elevated levels of total phosphorus and TSS were addressed through TP and TSS TMDLs. The remaining IBC-impaired segments were not addressed in this TMDL project.

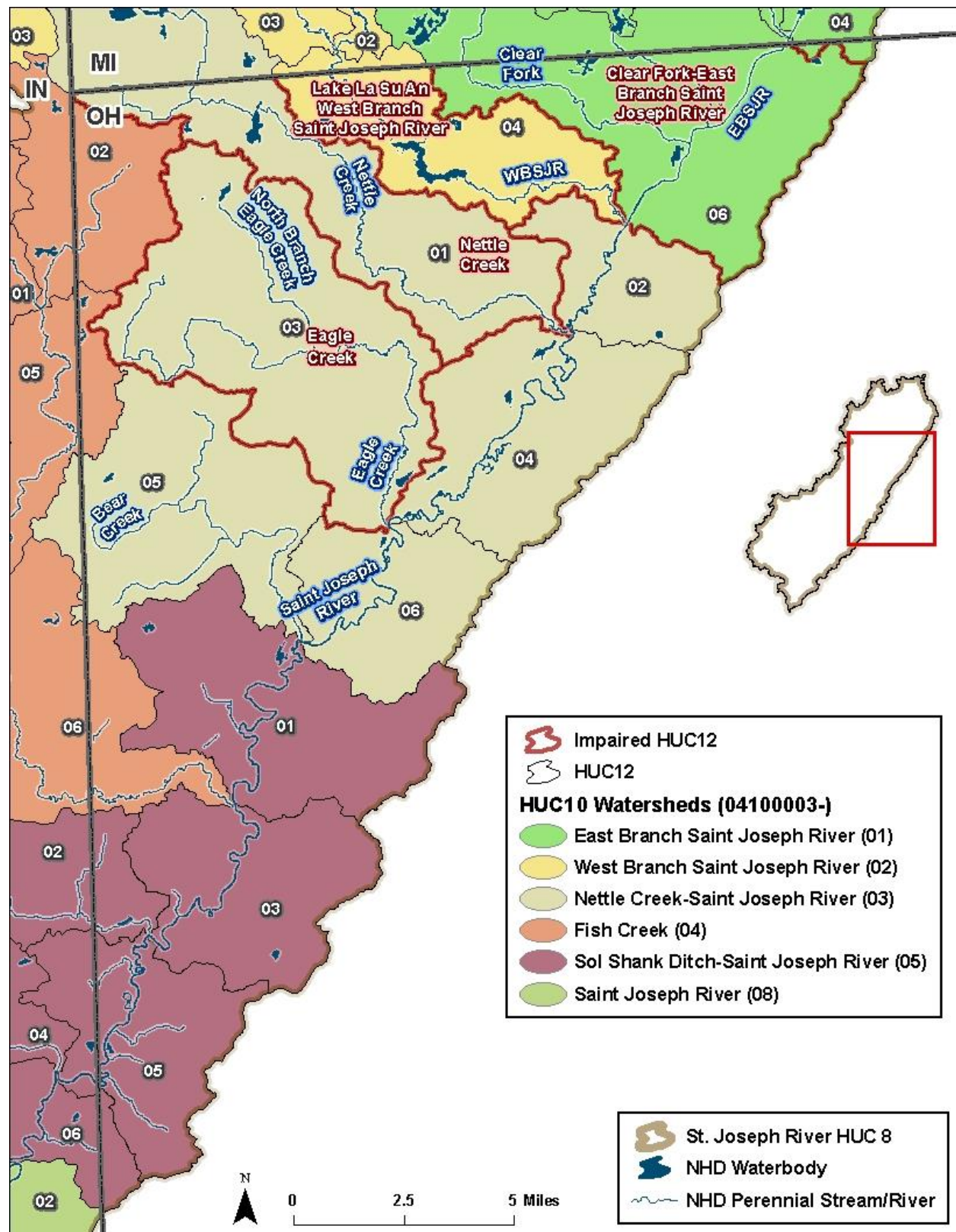


Figure 3. ALU impairments in Ohio's portion of the SJRW.

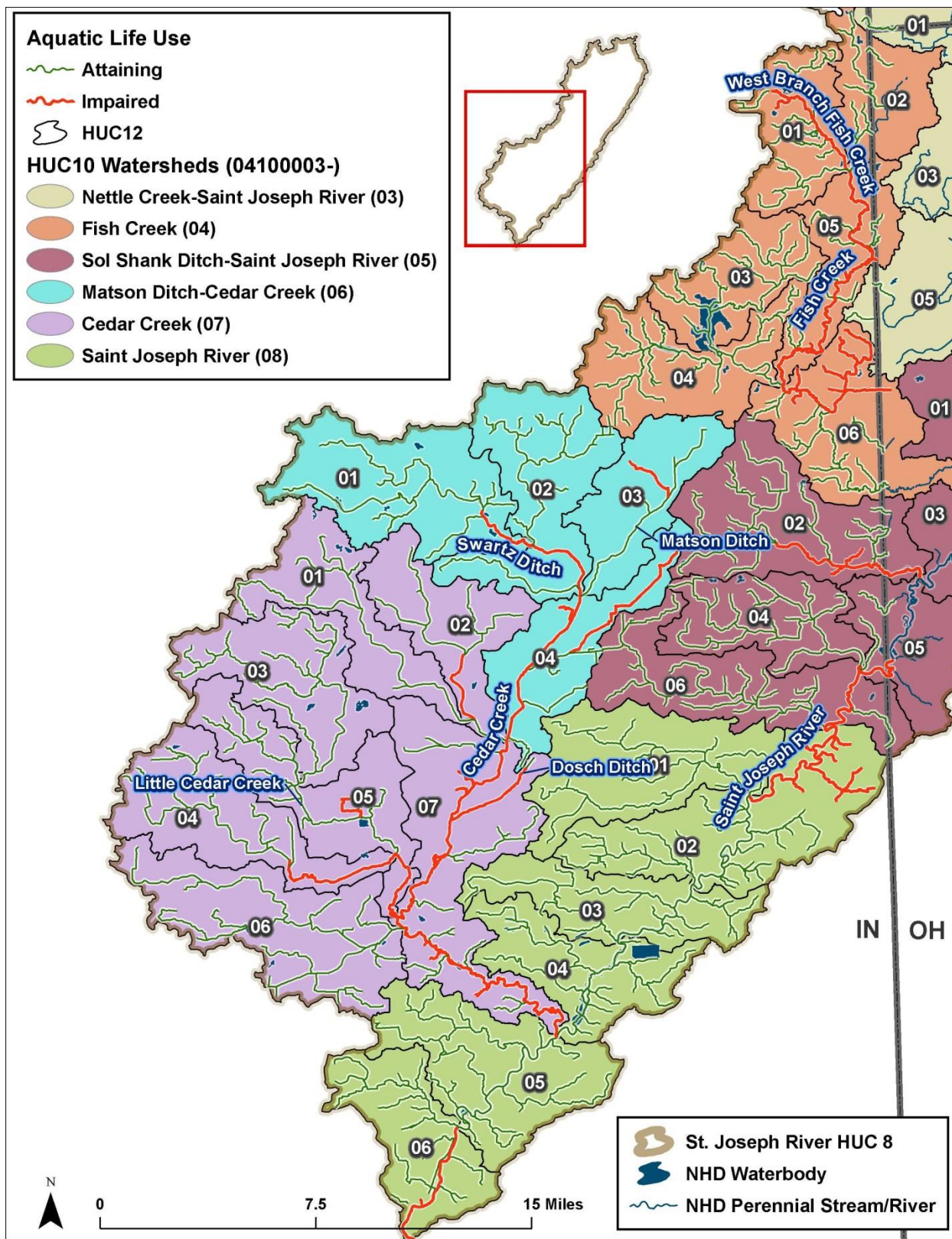


Figure 4. ALU impairments in Indiana's portion of the SJRW.

2.4.2 Recreation Uses

The SJR and its tributaries are not meeting their designated RUs¹⁵ due to excessive levels of *E. coli*.

2.4.2.1 Michigan

No RU impairments were identified by Michigan DEQ or included in Michigan's CWA 303(d) list in the 2014 Integrated Report (Michigan DEQ 2014b). No TMDLs will therefore be developed.

2.4.2.2 Ohio

As with ALU impairments, RU impairments evaluated in this TMDL project are based upon 2013 and 2014 monitoring data. These samples were not evaluated and impairments were not determined before the publication of Ohio's CWA 303(d) list in its draft 2014 Integrated Report (Ohio EPA 2014a)¹⁶. All fourteen sampled WAUs are impaired by *E. coli* (Figure 5; Table A-4 in Appendix A).

2.4.2.3 Indiana

The RU impairments are presented in Indiana's CWA (303(d) list (IDEM 2014c): two segments of the lower SJR (in HUC 04100003 08 02 and *08 03) and 59 segments across 16 12-digit HUs are impaired (Figure 6; Table A-6 in Appendix A).

¹⁵ In Michigan and Ohio, the designated uses are "recreation" uses, while in Indiana they are "recreational" uses. The term "recreational" is only used when referring to Indiana's designated uses.

¹⁶ Two 12-digit HUs were listed as category 5 for recreation use attainment in Ohio's 2014 303(d) list (Ohio EPA 2014a).

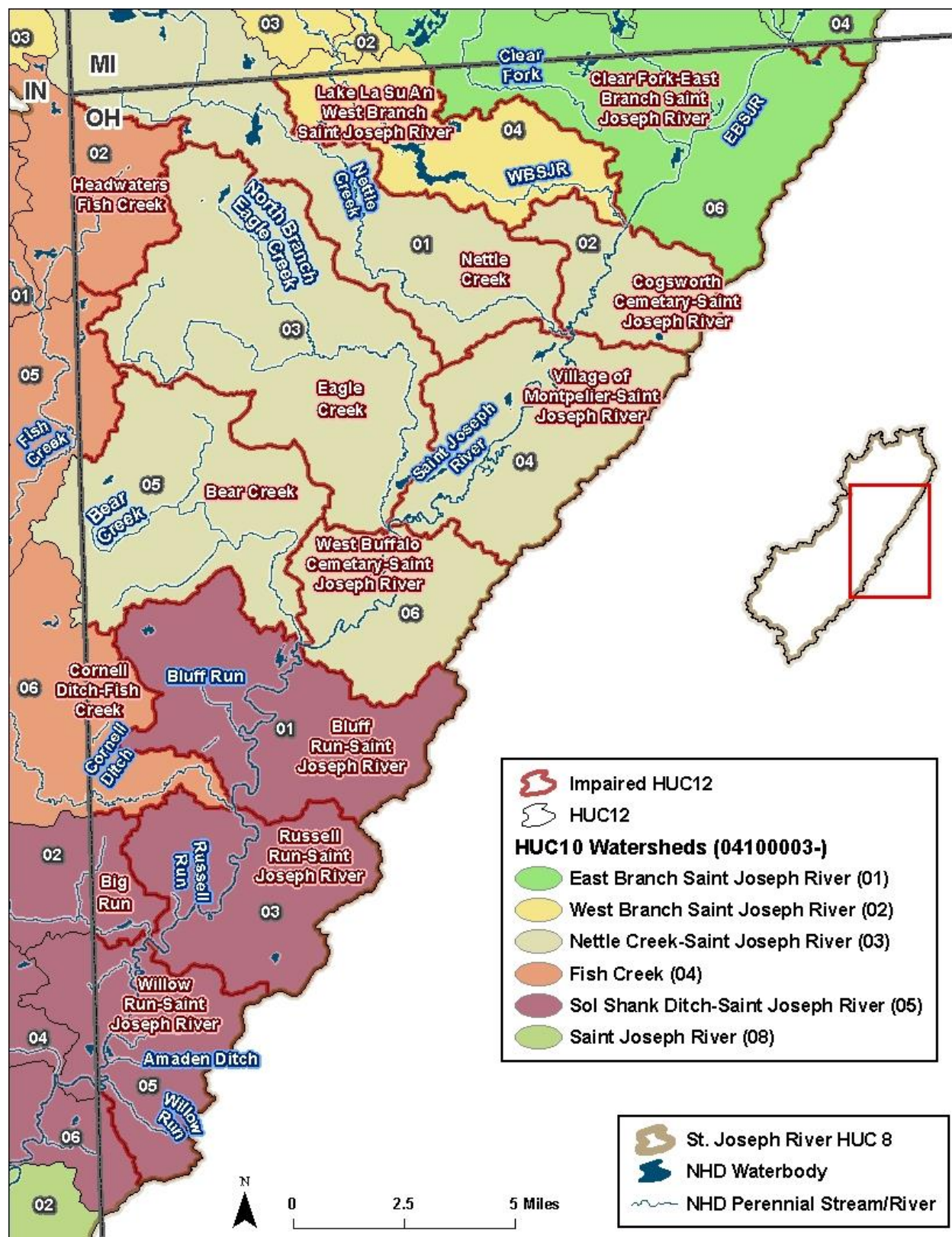


Figure 5. Recreation use impairments in Ohio's portion of the SJRW.

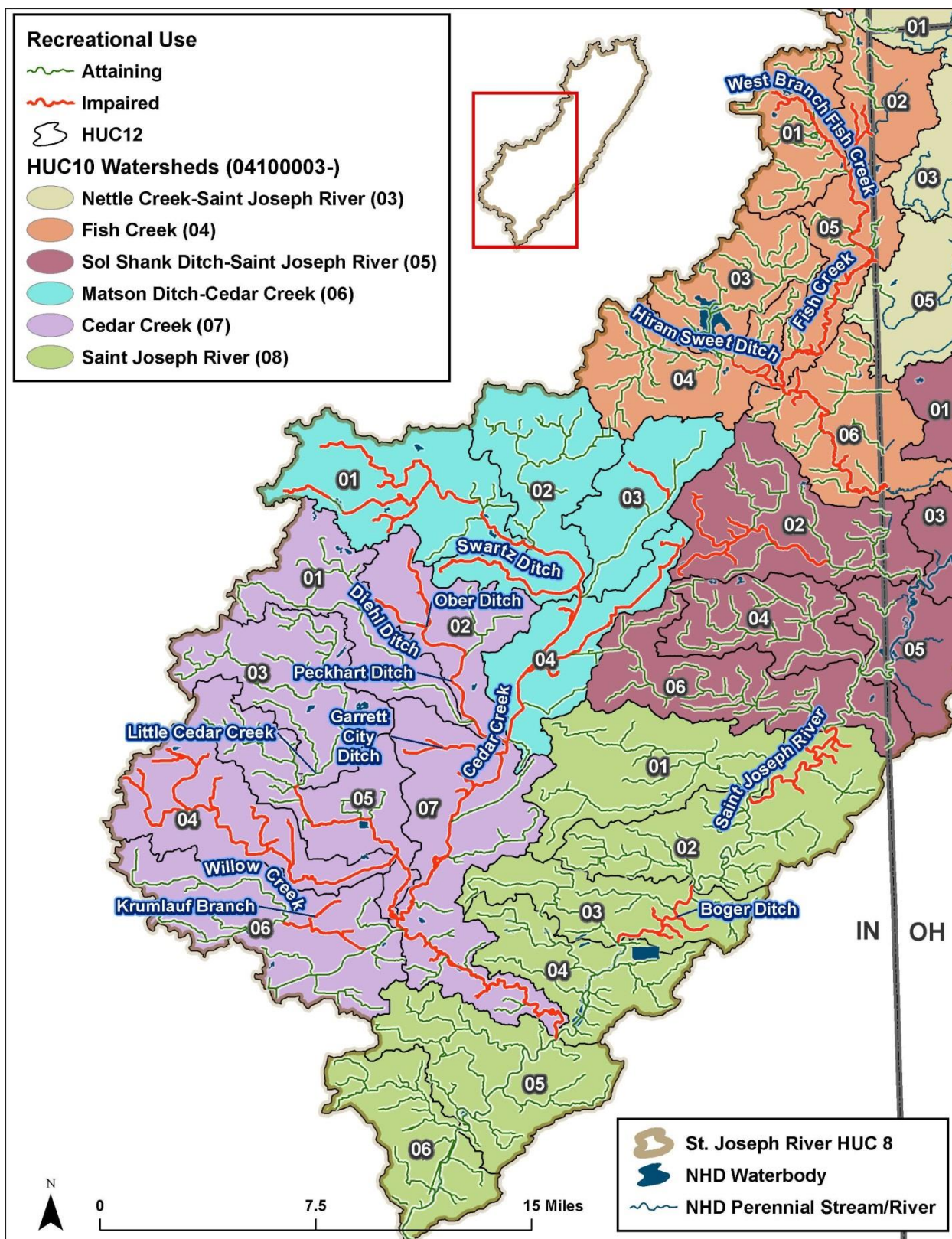


Figure 6. RU impairments in Indiana's portion of the SJRW.

3 Watershed Characterization

This section characterizes the SJRW and includes summaries of previous studies in the SJRW. A brief description of the Lake Erie Western Basin is also included because the SJR is a headwaters tributary to the Maumee River that discharges to Lake Erie in Toledo.

3.1 Lake Erie Western Basin

Lake Erie is the smallest, by volume, and shallowest of the Great Lakes. The Lake Erie basin is the most populated of the Great Lakes basins, with about one-third of the total Great Lakes basin population (Lake Erie LaMP 2011). Seventeen large metropolitan areas, including Detroit, MI; Windsor, Ontario; Toledo, OH; Cleveland, OH; and Buffalo, NY are in the Lake Erie basin (U.S. EPA 1995; see Figure 7). The lake provides drinking water to 11 million people (Lake Erie LaMP 2011). Fertile soils are located around the lake and intensely farmed, especially in northwest Ohio and southwest Ontario (U.S. EPA 1995).

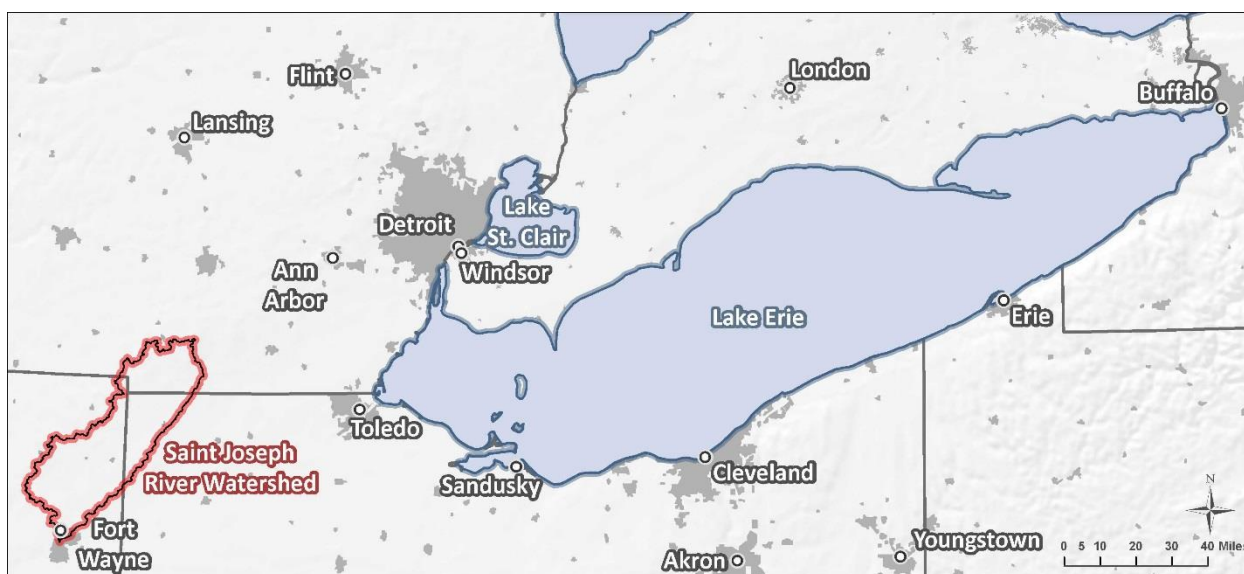


Figure 7. Lake Erie.

Lake Erie is commonly divided into three basins, which are described as follows (Lake Erie LaMP 2011):

- **Western Basin:** shallow with a mean depth of 24 feet and maximum depth of 62 feet
- **Central Basin:** average depth of 60 feet and maximum depth of 82 feet
- **Eastern Basin:** deep with an average depth of 80 feet and maximum depth of 210 feet

The water volume of the western basin is approximately one-fifth of Lake Erie (U.S.EPA 1995) but it drains about 65 percent of the Lake Erie watershed (Ohio EPA 2010c). The lake bottom of the western basin is covered with fine sediment and the western basin is turbid (Lake Erie LaMP 2011). Unlike the central and eastern basins, the western basin does not thermally stratify (Lake Erie LaMP 2011; Ohio EPA 2010c).

Ohio tributaries draining to the western basin (i.e., the Ottawa, Maumee, Toussaint, Portage, and Sandusky rivers) consist primarily of row-crop agriculture whereas tributaries draining to the central basin (i.e., the Huron, Vermillion, Black, Rocky Cuyahoga, Grand, and Ashtabula rivers) are about fairly evenly divided between row-crop agriculture, urban, and forest (Ohio EPA 2010c). The dominant land uses of the Ohio tributaries to Lake Erie is important because the majority of phosphorus loading to Lake

Erie is from “storm-pulsed runoff from the landscape into the tributaries that drain to Lake Erie” (Ohio EPA 2010c, p. 35). Ohio EPA (2013, p.5) has found that 61 percent of the total phosphorus load delivered to Lake Erie is from cultivated cropland. Causes of increased total phosphorus loading to Lake Erie from cropland are included in a summary of the sources of nutrient loading to Lake Erie that potentially cause harmful algal blooms (Smith et al. 2015).

The U.S. and Canadian governments have agreed to reduce phosphorus entering Lake Erie by 40 percent. By reaching the 40 percent targets, the two countries hope to minimize low oxygen “dead zones” in the central basin of Lake Erie, maintain healthy aquatic ecosystems, and keep algal blooms at levels that do not produce toxins that pose a threat to human or ecosystem health.

Additional characteristics of the Western Basin of Lake Erie with special focus upon nutrients, sediment, and other water quality issues is presented in the following documents:

- *Combined Coastal Management Program and Final Environmental Impact Statement for the State of Ohio* (Ohio Department of Natural Resources 2007)
- *Lake Erie Binational Nutrient Management Strategy: Protecting Lake Erie by Managing Phosphorus* (Lake Erie LaMP 2011)
- *Ohio Lake Erie Phosphorus Task Force Final Report* (Ohio EPA 2010c)
- *Ohio Lake Erie Phosphorus Task Force II Final Report* (Ohio EPA 2013)
- *Status of Nutrients in the Lake Erie Basin* (Lake Erie LaMP 2009)
- *The Great Lakes: An Environmental Atlas and Resource Book* (U.S. EPA 1995)

3.2 Previous Studies

IDEM, Michigan DEQ, Ohio EPA, SJRWI, Purdue University, and other entities have previously studied the SJRW. Section B-1 of Appendix B provides a summary of selected previous work. Additional studies regarding specific topics (e.g., SJRWI’s conservation tillage study) are referenced throughout this report.

3.3 Project Setting

The SJRW (HUC 04100003) is in south central Michigan, northwest Ohio, and northeast Indiana. “Originating in Hillsdale County, Michigan, the SJR flows southwest through Williams and Defiance[c]ounties, Ohio, and DeKalb and Allen [c]ounties, in Indiana, to join with the St. Mary’s River at Fort Wayne to form the Maumee River” (Ohio EPA 1994a, p. 10). The Tiffin River (HUC 04100006) watershed borders the SJRW to the east; the upper Maumee River watershed (HUC 04100005) to the southeast; the St. Mary’s River watershed (HUC 04100004) to the south and the Eel River watershed (HUC 05120104; a tributary to the Wabash River) to the west. Another SJRW (HUC 04050001) that drains to Lake Michigan borders this SJRW (HUC 04100003) to the west and north. The Fort Wayne metropolitan area is within the southern end of the basin.

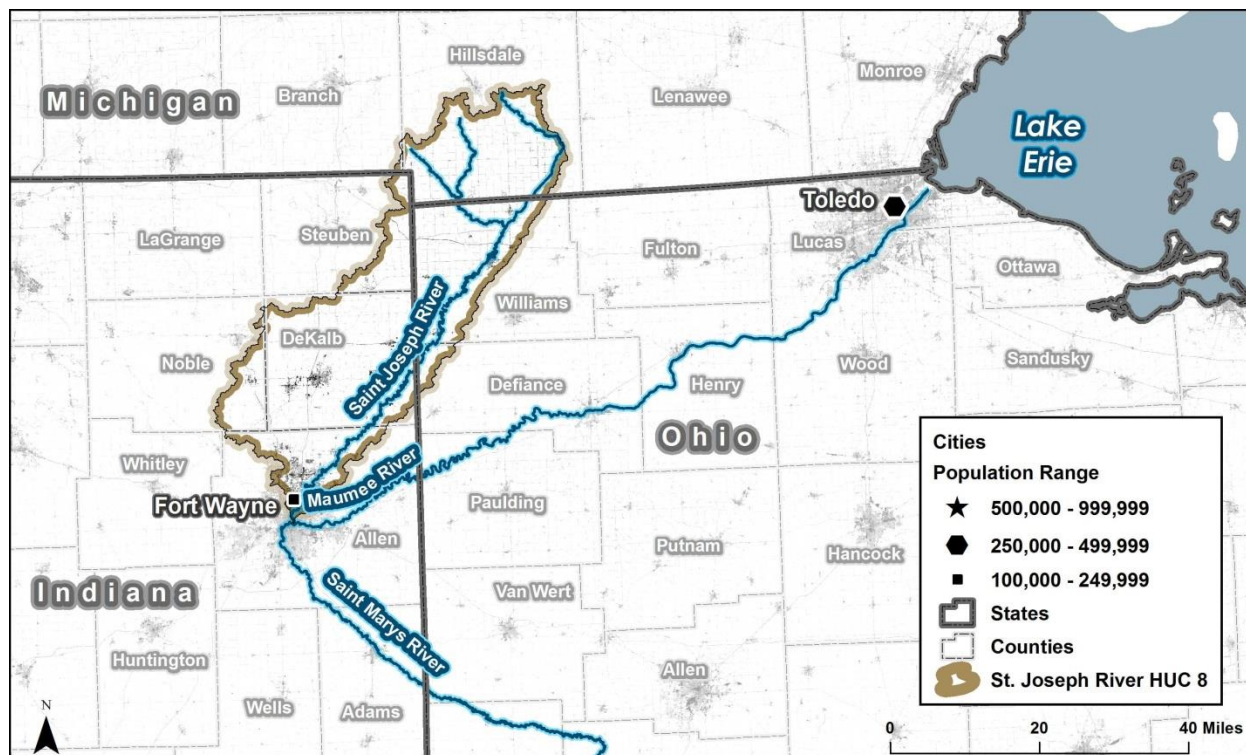


Figure 8. SJR in Lake Erie's Western Basin.

The SJRW drains about 1,085 square miles across eight counties¹⁷ and the majority of the basin is in three counties (Hillsdale [MI], DeKalb [IN], and Williams [OH]). Fort Wayne, IN, is the largest city in the basin, followed by the cities of Auburn (IN), Garrett (IN) and the village of Montpelier (OH; Figure 9). The Ohio turnpike (Interstate 80/90) runs east-west through the northern portion of the SJRW; the major east-west U.S. routes in the watershed are U.S. routes 6 and 20. Interstate 69 runs north-south through the western portion of the watershed; the major north-south highway is U.S. route 27.

¹⁷ The eight counties are Allen, DeKalb, Noble, and Steuben counties in Indiana; Branch and Hillsdale counties in Michigan; and Defiance and Williams counties in Ohio.

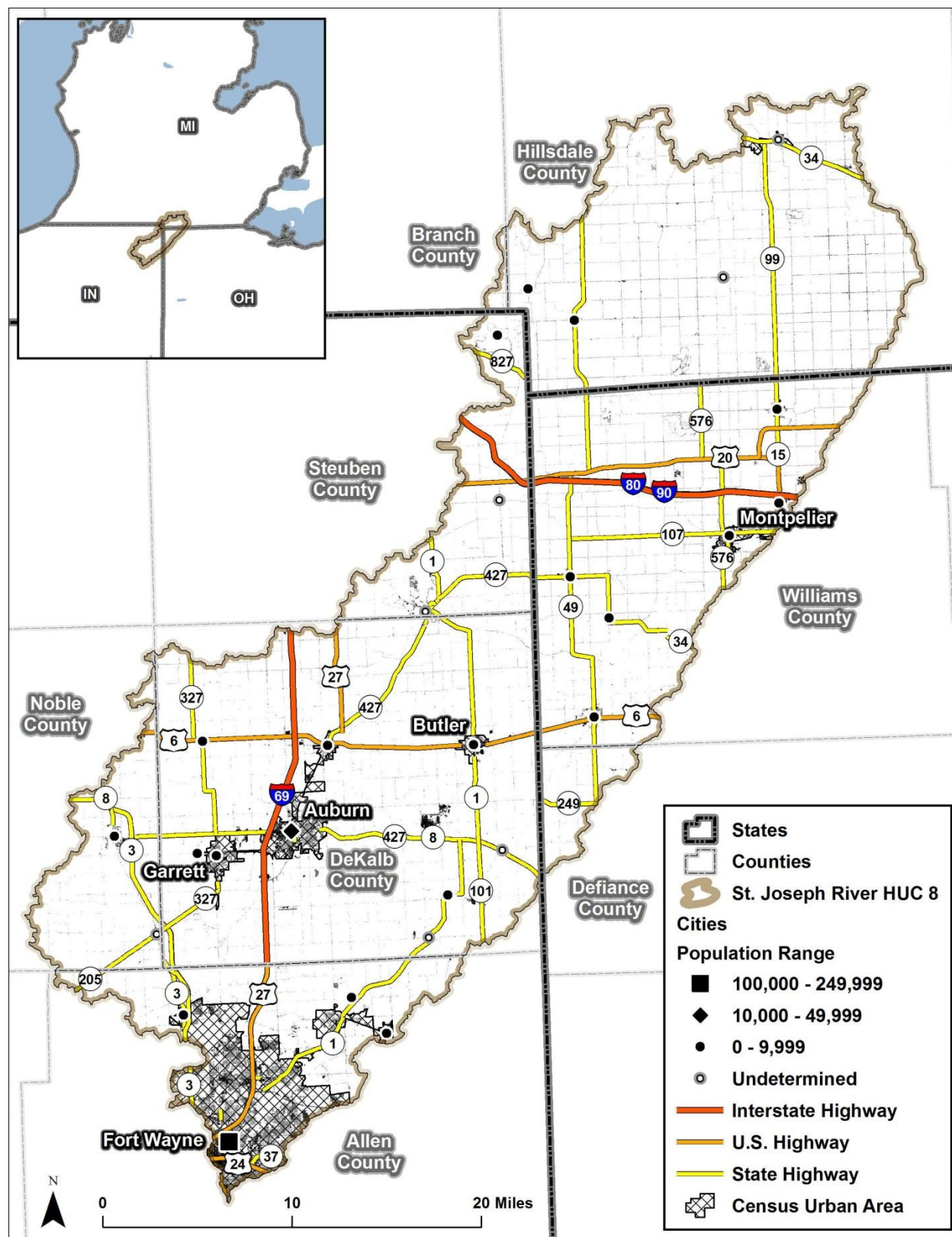


Figure 9. Major roads and population centers in the SJRW.

3.4 Land Use and Land Cover

The SJRW is primarily rural with little urban land outside of one large metropolitan area (Fort Wayne) and a few small municipalities (SJRWI 2008). Like other watersheds in northeast Indiana and northwest Ohio, the SJRW is dominated by agricultural land use, including both cultivated row crops and pastureland for livestock grazing (Table 5; Figure 10). Agricultural drain tiles are installed for row crop agriculture to drain the wetlands that existed prior to settlement (Quandt nd).

The land use is predominantly agricultural (69 percent) and includes deciduous forest (11 percent), woody wetland (7 percent), developed open space (6 percent), and developed land (5 percent). The remaining 3 percent (due to rounding) are small areas of other land uses (e.g., grasslands, open water). In 1992, about 57 percent of the land was in crop production, and 14 percent was enrolled in the Conservation Reserve Program (CRP; Ohio EPA 1994, p. 10). In addition to lands held in CRP, lands were also held in the Environmental Quality Incentives Program (EQIP) and the Wetland Reserve Program (WRP; SJRWI 2008). In addition to row crop agriculture, which is typically corn and soybeans with some grain or hay, agricultural lands are also used as pasture and for livestock production (Quandt nd, p. 24). A map of the 2013 Crop Data Layer from the USDA is presented in Figure B-1 of Appendix B.

Agricultural drain tiles were installed in the SJRW to lower the water table for crop production and channels and ditches were installed to efficiently route water. Both practices significantly affect the hydrology of the region and affect the water quality of the streams due to rapid delivery of excess nutrients into the streams. Many parks, preserves, and reservations are operated by government or private entities, including three state-owned wildlife areas: Fish Creek Wildlife Area, Lake La Su An Wildlife Area, and Lost Nations State Game Park (SJRWI 2006). Several parks, a fairground, and fishing access are also protected (Ohio EPA 2015a, p. 14). These areas, which include wetlands and marshes, are protected from agricultural development.

Developed land in the project area also includes rural towns and a few urban cities. A map of impervious cover is presented in Figure B-2 in Appendix B. Both combined sewer systems and regulated Phase II municipal separate storm sewer systems (MS4s) are in the project area. Phase II MS4s serve populations of fewer than 100,000 and cover the portion of the MS4 located within the Urbanized Area, as defined by the U.S. Census or as designated by rules promulgated by IDEM, Michigan DEQ, or Ohio EPA. Combined sewer systems in the project area are discussed in Section 4.2.2.1 and regulated MS4s are discussed in Section 4.2.5.

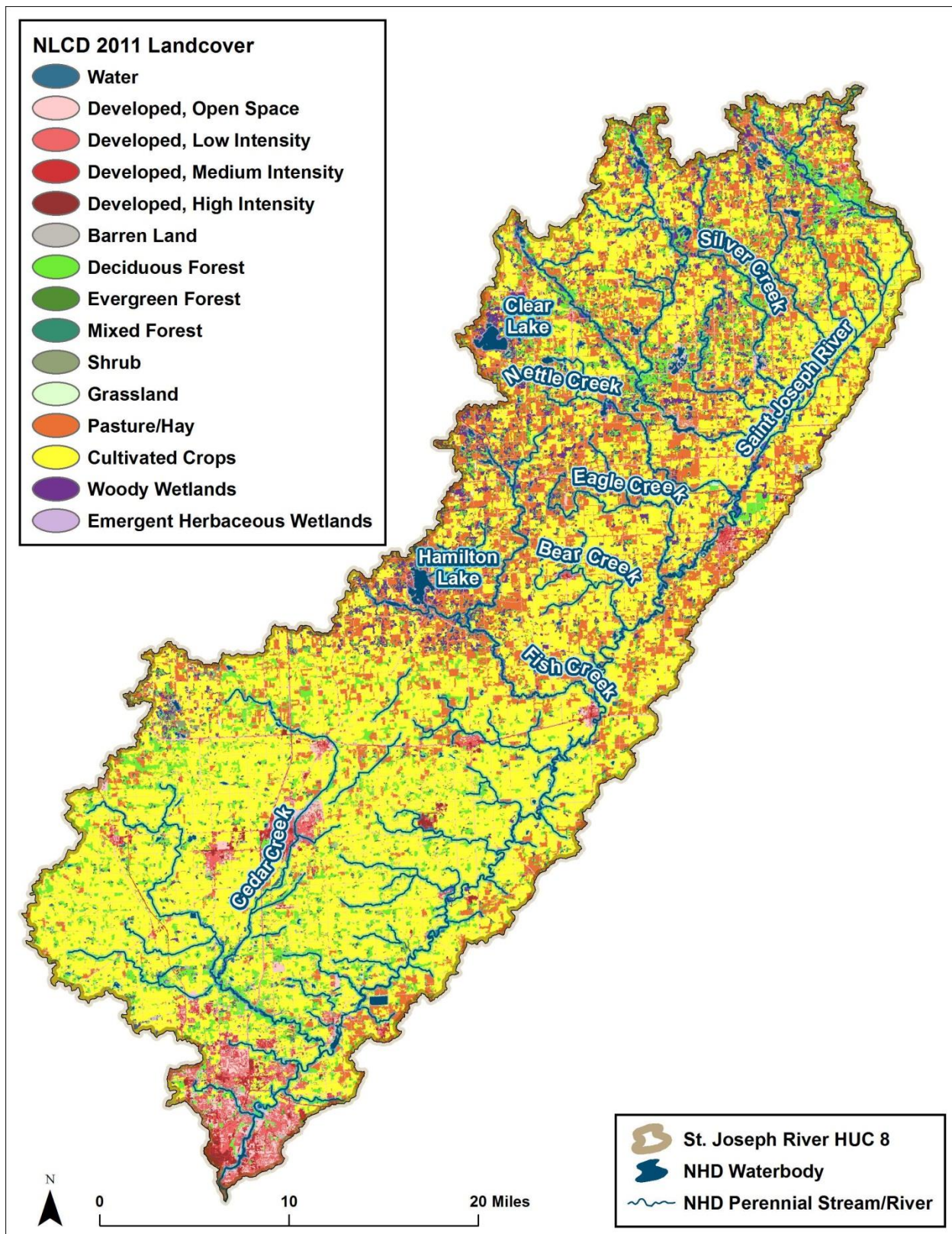
Table 5. Land cover in the SJRW

Land cover class	Acres	Percent	Land cover class	Acres	Percent
Open Water	8,644	1%	Mixed forest	334	<1/2%
Developed, open space	40,810	6%	Shrub/scrub	3,751	1%
Developed, low intensity	22,621	3%	Grassland/herbaceous	2,612	<1/2%
Developed, medium intensity	7,712	1%	Pasture/hay	118,961	17%
Developed, high intensity	3,066	<1/2%	Cultivated crops	361,974	52%
Barren land	548	<1/2%	Woody wetlands	48,971	7%
Deciduous forest	76,503	11%	Emergent herbaceous wetlands	2,763	<1/2%
Evergreen forest	1,365	<1/2%			

Source: 2011 National Land Cover Dataset (Jin et al. 2013).

Acreages and percentages were rounded to the nearest integer.

A double dash ("--") indicates that a land cover was not present.



Source: 2011 National Land Cover Dataset (Jin et al. 2013).

Figure 10. Land cover in the SJRW.

3.5 Geology and Soils

The glacial advance and retreat of the Wisconsinian glaciation were highly influential in the topography, geology, and soils that developed in the region. In general, as glaciers advanced, existing rocks and soils were eroded repeatedly. These materials were re-deposited as sediments during several ice advance, melt, and retreat cycles. Such glacial materials were deposited as sands, gravels, silts, and clays; the melt water created large rivers, which carried and spread the deposited glacial materials throughout the region. Glacial deposits and associated land forms exerted a major effect that influences present day hydrology, soil types, and land cover.

The topography of the SJRW is rolling hills in the northern portion of the watershed, and nearly level plains in DeKalb and Allen counties in the southern portion of the watershed (SJRWI 2006). The surficial geology of the SJRW is described as

“[D]istinguished by gently rolling glacial till plain with moraines, kames, and outwash plains. Local relief is usually less than 50 feet. Soils of the watershed reflect the glacial history, having been formed mainly in glacial till or glacial outwash.” (Ohio EPA 1994a, p. 10)

3.5.1 Ecoregion Overview

The SJRW is in the Eastern Corn Belt Plains (ECBP) level III ecoregion #55 and the Southern Michigan/Northern Indiana Drift Plains (HELP) level III ecoregion #56 (Figure B-3 of Appendix B). The general physiography and geology and soils of the three corresponding level IV ecoregions are described in Table B-1 and Table B-2; Figure B-4 presents a map of the level IV ecoregions. Level IV ecoregions are at the finest ecoregional scale and are used to evaluate very localized characteristics.

3.5.2 Geology

The bedrock underling much of the SJRW is shale or black shale that was deposited during the Devonian or Mississippian ages from 300 million to 360 million years ago (Quandt 2015, p. 8). While most of the SJRW is underlain by shale, the Fort Wayne area is underlain by limestone and portions of tributaries' headwaters are underlain by sandstone (Figure B-5 in Appendix B). Quandt (2015, p. 8) also describes the unconsolidated deposits of the surficial geology as “glaciofluvial material” composed of sand and gravel or loamy till that overlies deeper clay deposits. Sediment can be more than 200 feet thick when overlying bedrock in northeast Indiana and southeast Michigan (Myers et al. 2000, p. 6).

3.5.3 Soils

The National Cooperative Soil Survey publishes soil surveys for each county in the United States. Soil surveys contain predictions of soil behavior and also highlight limitations and hazards inherent in the soil, general improvements needed to overcome the limitations, and the effect of selected land uses on the environment. The soil surveys are designed for many different uses, including land use planning.

Soil surveys contain predictions of soil behavior and provide data related to different soil types, including the hydrologic soil groups (HSGs). HSG refers to the grouping of soils according to their runoff potential. Soil properties that influence HSGs include depth to seasonal high water table, infiltration rate and permeability after prolonged wetting, and depth to slow permeable layer. There are four HSGs: Groups A, B, C, and D; descriptions of the HSGs are in Table B-3 of Appendix B.

“Soils in the watershed were formed from compacted glacial till” (SJRWI 2006, p. 9). Soils in the SJRW are “moderately to somewhat poorly drained [...] with moderate runoff potential” (Myers et al. 2000, p. 1). Using the soil surveys for each county in GIS, the HSGs were analyzed in GIS. Soils in the SJRW are typically D, C, and C/D (Figure 10; Table B-4) with a shallow groundwater table. Due to extensive agricultural drain tiling, much of the A/D, B/D, and C/D soils will act as A, B, or C soils, respectively.

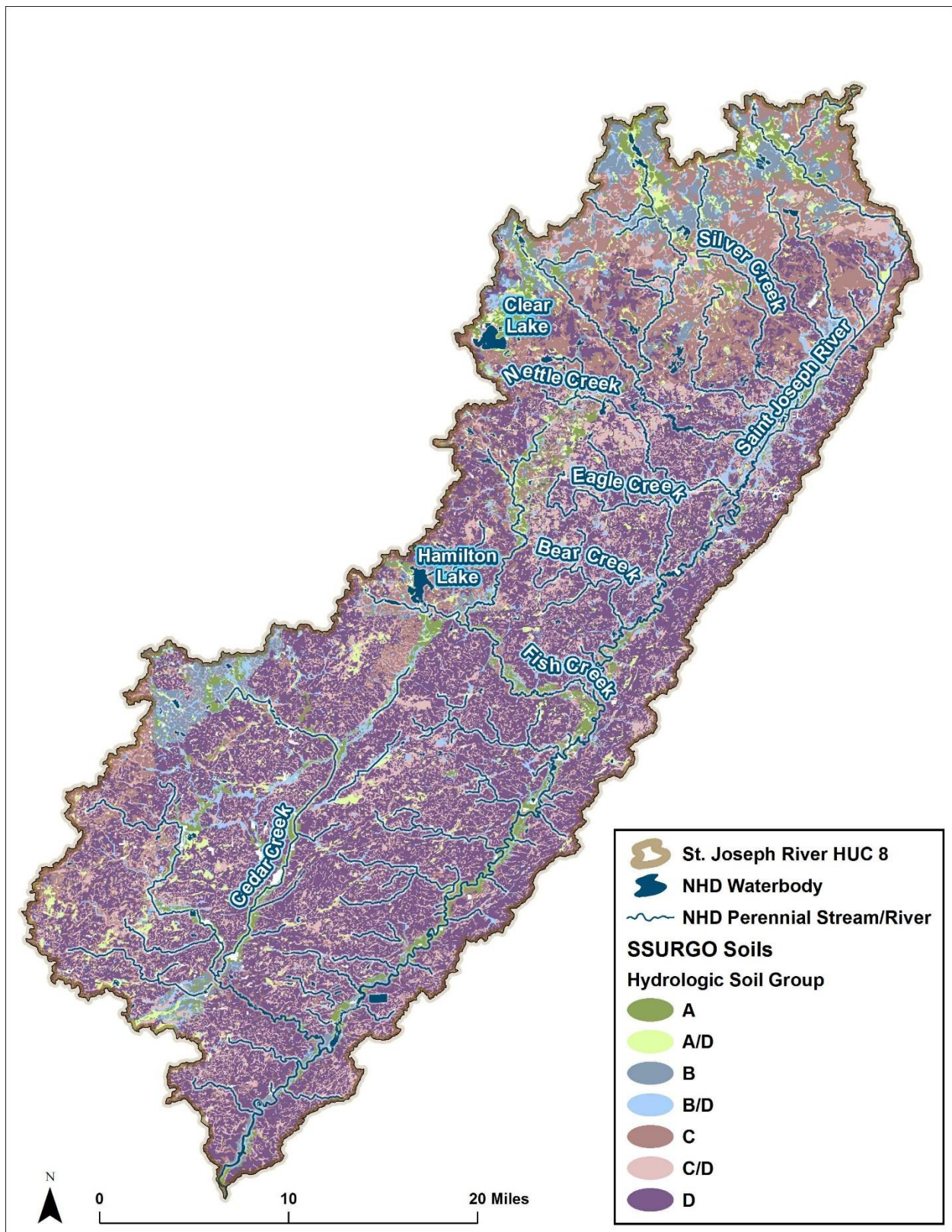


Figure 11. Hydrologic soil groups in the SJRW.

3.6 Climate

The climate of the SJRW is described as “temperate with warm summers and cold winters” (Quandt nd, p. 16). As part of the Great Lakes Region, the climate in the SJRW is determined primarily by westerly atmospheric circulation, the latitude, and the local modifying influence of nearby Lake Erie (Derecki 1976). Climate in the Great Lakes basin is further described as follows (U.S. EPA 1995, Chapter 2, Section 2)

The weather in the Great Lakes basin is affected by three factors: air masses from other regions, the location of the basin within a large continental landmass, and the moderating influence of the lakes themselves. The prevailing movement of air is from the west. The characteristically changeable weather of the region is the result of alternating flows of warm, humid air from the Gulf of Mexico and cold, dry air from the Arctic.

These factors tend to increase humidity and can create lake effect precipitation during the cold fall and winter months. Despite that, the proximity to Lake Erie also moderates the local climate as the large waterbody acts as a heat sink or source, warming the air in cold months and cooling the air in the summer. “The average length of the growing season is about 156 days” (SJRWI 2008, p. 25).

Weather data from four gages were obtained from the Western Reserve Climate Center (WRCC 2014): Angola, IN (station 120200; 1893-2014), Fort Wayne, IN (station 14827; 1942-2014), Hillsdale, MI (station 203823; 1891-2014), and Montpelier, OH (station 335438; 1893-2014). Winter monthly average low temperatures across the four sites ranged from 15 to 22 degrees Fahrenheit while summer monthly average high temperatures ranged from 79 to 85 degrees Fahrenheit. Precipitation at the three sites ranged from 35 to 37 inches per year with 30 to 44 inches as snowfall. The data for Fort Wayne are summarized in Figure 12; similar figures for Angola, Hillsdale, and Montpelier are in Appendix B.

Examination of precipitation patterns is a key part of watershed characterization. In particular, rainfall intensity and timing affect watershed response to precipitation. This information is important in evaluating the effects of stormwater on the tributaries. Figure 13 presents one method to assess rainfall intensity; similar figures for Angola, Hillsdale, and Montpelier are presented in Appendix B. The WRCC data show that 34 to 45 percent of the precipitation events per year are less than 0.1 inches and that 5 to 7 percent are greater than 1 inch.

Table 6. Climate data summary for Fort Wayne, Indiana (station 14827)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High Temperature	31.9	35.3	46.7	60.2	71.4	80.8	84.3	82.3	75.7	63.8	48.9	36.1
Low Temperature	17.0	19.4	28.5	38.8	49.2	59.2	62.8	60.8	52.9	42.1	32.5	22.0
Precipitation	2.3	2.1	2.9	3.6	4.0	4.0	3.9	3.5	2.8	2.7	2.8	2.5
Snowfall	9.0	7.4	4.8	1.2	0.0	0.0	0.0	0.0	0.0	0.2	2.6	7.4

Source: WRCC 2014.

Notes

Summary of data collected at Fort Wayne, IN National Climactic Data Center station 14827 from January 1, 1942 through October 23, 2014.

- a. All four parameters are monthly averages. High and low temperatures are in degrees Fahrenheit. Average precipitation is in inches water equivalent. Average snowfall is in inches of snow.

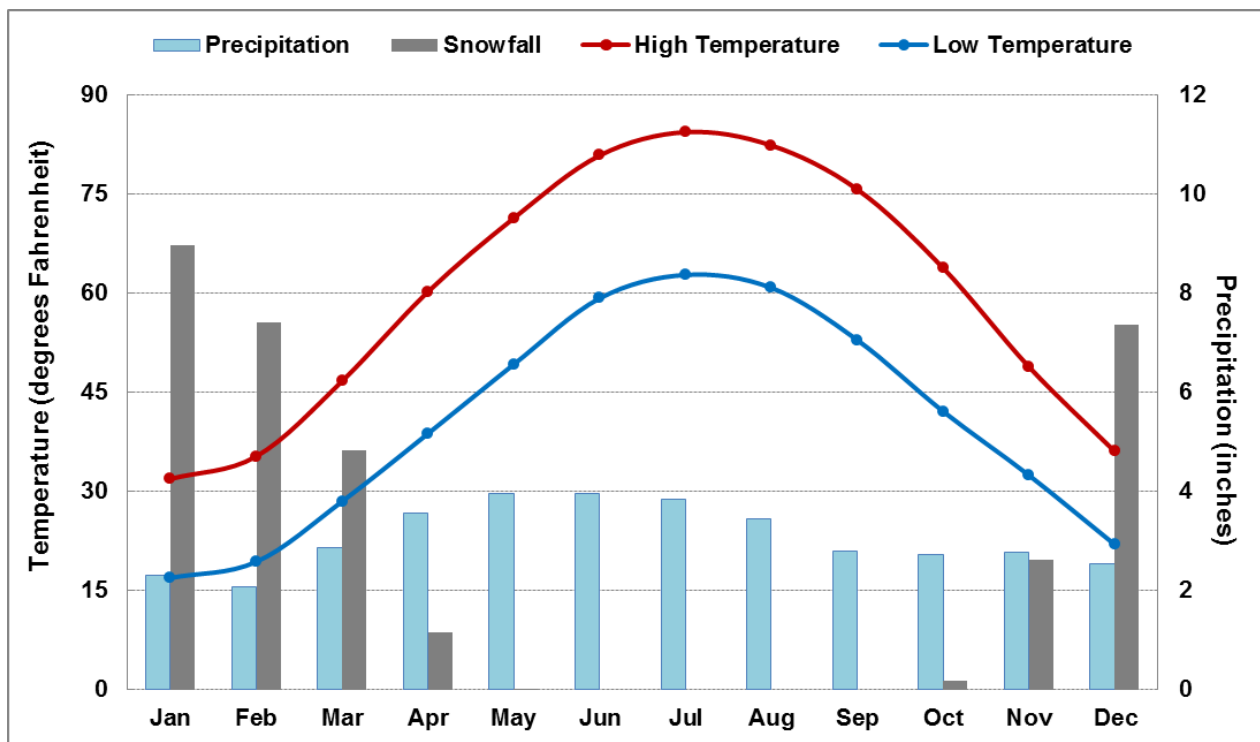


Figure 12. Temperature and precipitation summary at Fort Wayne, IN (station 14827).

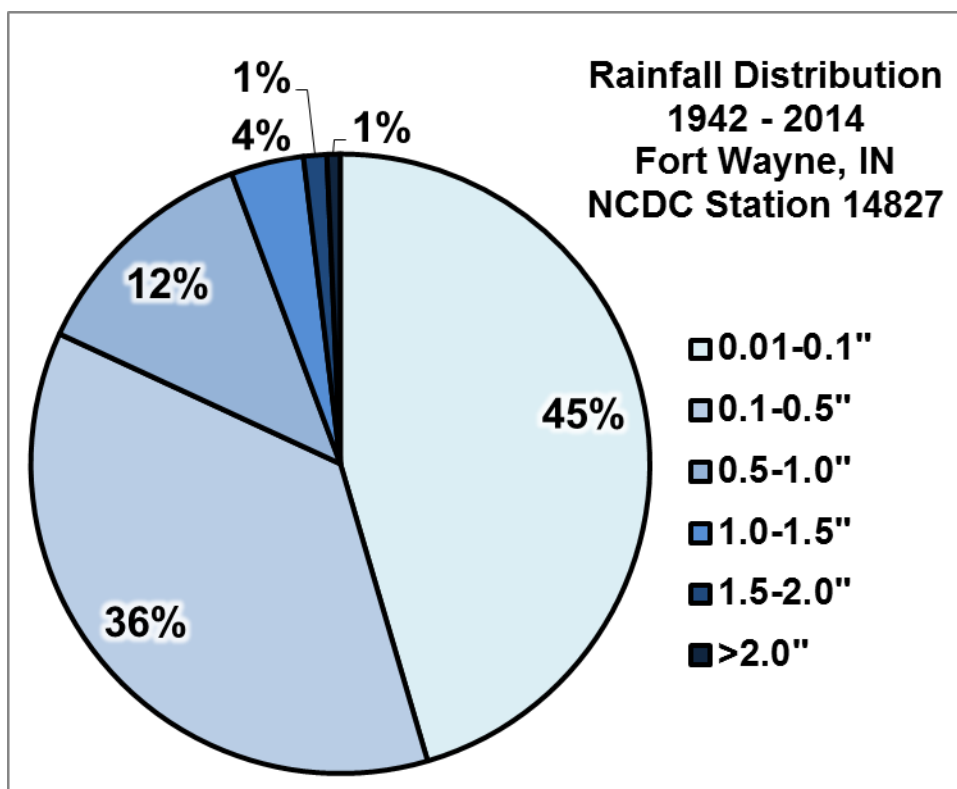


Figure 13. Precipitation intensity at Fort Wayne, IN (station 14827).

3.7 Hydrology

Hydrology plays an important role in evaluating water quality. In the project area, hydrology is primarily driven by local climate conditions. This includes situations that often result in flashy flows, where the stream responds to and recovers from precipitation events relatively quickly. Flashy flows are prominent in the East and West Branches of the St. Joseph River in Michigan (Michigan DEQ 2005). Flow regime alterations due to anthropogenic activities not only affect aquatic life but also affect humans.

“The present-day river is a wide and relatively slow-flowing stream with an average slope of 1.6 feet per mile, following the Fort Wayne moraine” (SJRWI 2006, p. 6). In Michigan, the average gradients of the East and West forks of the West Branch of the St. Joseph River are 5.5 and 7.0 feet per mile (respectively), while the average gradients in the tributaries to the East Branch range from 5 to 11 feet per mile (Michigan DEQ 2005). Generally, the headwaters tributaries in the SJRW have slopes of about 10 feet per mile (Myers et al. 2000, p. 6).

The SJR is impounded in Leo-Cedarville, at the Cedarville Dam, to create the Cedarville Reservoir (SJRWI 2008). The river is also impounded by the St. Joseph Dam in Fort Wayne near the intersection of Coliseum and North Anthony boulevards. Water withdrawn at the St. Joseph Dam is piped to Fort Wayne’s Three Rivers Filtration Plant. Besides the reservoirs, small ponds to large lakes are present throughout the SJRW. SJRWI (2006, p. 10) identified 17 “sizeable inland lakes,” including Cedarville Reservoir (IN), Clear Lake (IN), Hurshtown Reservoir (IN), Nettle Lake (OH), and Seneca Lake (OH)¹⁸. Cedarville and Hurshtown reservoirs are owned by Fort Wayne. Ohio EPA (2015, p. 40-47) discusses Ohio’s inland lake monitoring, lake uses, and habitat for Barton, McKarns, and Nettle lakes.

Water is withdrawn for agricultural operations, community water systems, and NPDES permittees for industrial use. Much of the SJRW relies on groundwater for public water supply; groundwater is also used for some agricultural and industrial operations. The northeast portion of the SJRW is underlain by the Michindoh aquifer. The entire population in the middle St. Joseph River area (i.e., the *Sol Shank Ditch-St. Joseph River* HU; HUC 04100003 05) uses the Michindoh aquifer for potable water (Rice 2005), including Butler, IN, and Edgerton, OH. In Michigan, groundwater is the source of water for the community water systems and NPDES permittees in the SJRW¹⁹. Except for one surface water withdrawal, the Winwood Hollow Golf Course²⁰, all the withdrawals in Ohio are from groundwater. Indiana Department of Natural Resources (IDNR) data indicate that 142 water withdrawals are in the Indiana-portion of the SJRW (IDNR 2015a,b; Figure C-7 in Appendix C). Of these 142 withdrawals, 25 withdrawals are from surface waters, but only 8 withdrawals are from streams and rivers. The Three Rivers Filtration Plant (i.e., Fort Wayne public water supply) withdrawals from the lower SJR are the largest withdrawals (128 cfs capacity); the other seven withdrawals are considerably smaller.²¹ Three Rivers Filtration Plant daily withdrawal data indicate that the WTP typically withdraws 50 cfs from the St. Joseph River (Fort Wayne 2015).

Anthropogenic activities that alter the natural flow regime in the SJRW are not limited to reservoir construction and urbanization. Hydrology is also affected by the conversion of forest land to agricultural land and the installation of subsurface tiles to improve drainage. That practice is generally referred to as *field tiling* and involves subsurface drains (e.g., corrugated plastic tile or pipe) installed below the surface that serve as conduits to collect or convey drainage water, either to a stream channel or to a surface field

¹⁸ Refer to SJRWI (2006, p.10) for a table of lakes, locations, drainage areas, surface areas, and depths.

¹⁹ In Michigan, agricultural water use data are confidential and cannot be disclosed to the public

²⁰ From 2005 through 2013, withdrawals at the Winwood Hollow Golf Course ranged from 40,000 gallons per year to 11,670,000 gallons per year (average: 3,260,000 gallons per year), excluding the years 2007 and 2010 when no surface water was withdrawn.

²¹ The Willow Ridge Golf Club has withdrawal capacities of 0.4 cfs, 1.2 cfs, and 1.2 cfs from Willow Creek; Rainmaker Farms has a withdrawal capacity of 1.0 cfs from the St. Joseph River, and two private individuals have withdrawal capacities of 0.2 cfs from Yoho Branch of Sol Shank Ditch and 1.2 cfs from the St. Joseph River.

drainage ditch. While the drainage improvements increase the amount of land available for cultivation, they also influence the hydrology, aquatic habitat, and water quality of area streams. SJRWI (2006) identified many streams in the SJRW that were “channelized and straightened to improve the flow of water downstream.”

The U.S. Geological Survey (USGS) maintains flow gages at several locations on the SJR (Table 7) and its tributaries (Table 8); the locations of the gages are shown on Figure 14. USGS also operates a continuously recording gage on the Maumee River below the confluences of the St. Joseph and St. Mary’s rivers that form the Maumee River: Maumee River at Coliseum Boulevard at Fort Wayne, IN (gage 04182950). USGS also reports peak flow and instantaneous flow (see Table B-8 in Appendix B) at numerous additional locations throughout the watershed. Average daily mean flow data per day for the two active USGS gages from water years (WYs) 1994 through 2013 are presented in Figure B-13 and flow duration curves are presented in Figure B-14.

Table 7. USGS continuously recording stream gages on the SJR

Gage ID	Location	Area (mi. ²)	Period of record (water years)
04177500	St Joseph River near Blakeslee OH	394	1926 - 1932
04178000	St. Joseph River near Newville, IN	610	1946 - present
04178500	St. Joseph River at Hursh, IN	734	1951 - 1953
04179000	St. Joseph River at Cedarville, IN	763	1900 1931 - 1932 1955 - 1982
04180500	St. Joseph River near Fort Wayne, IN	1,060	1941 - 1955 1984 - present

Notes

Gages are listed from top to bottom from headwaters to mouth.

The period of record for daily mean flows is displayed, and the data are provisional for water years 2014 and 2015.

Table 8. USGS continuously recording stream gages on tributaries of the SJR

Gage ID	Location	Area (mi. ²)	Period of record (water years)
04177720	Fish Creek at Hamilton, IN	37.5	1970 - present
04177810	Fish Creek near Artic, IN	98	1988 - 2007
04179500	Cedar Creek at Auburn, IN	87.3	1944 - 1973
04180000	Cedar Creek near Cedarville, IN	270	1947 - present

Notes

Gages are listed from top to bottom numerically by gage ID.

The period of record for daily mean flows is displayed, and the data are provisional for water years 2014 and 2015.

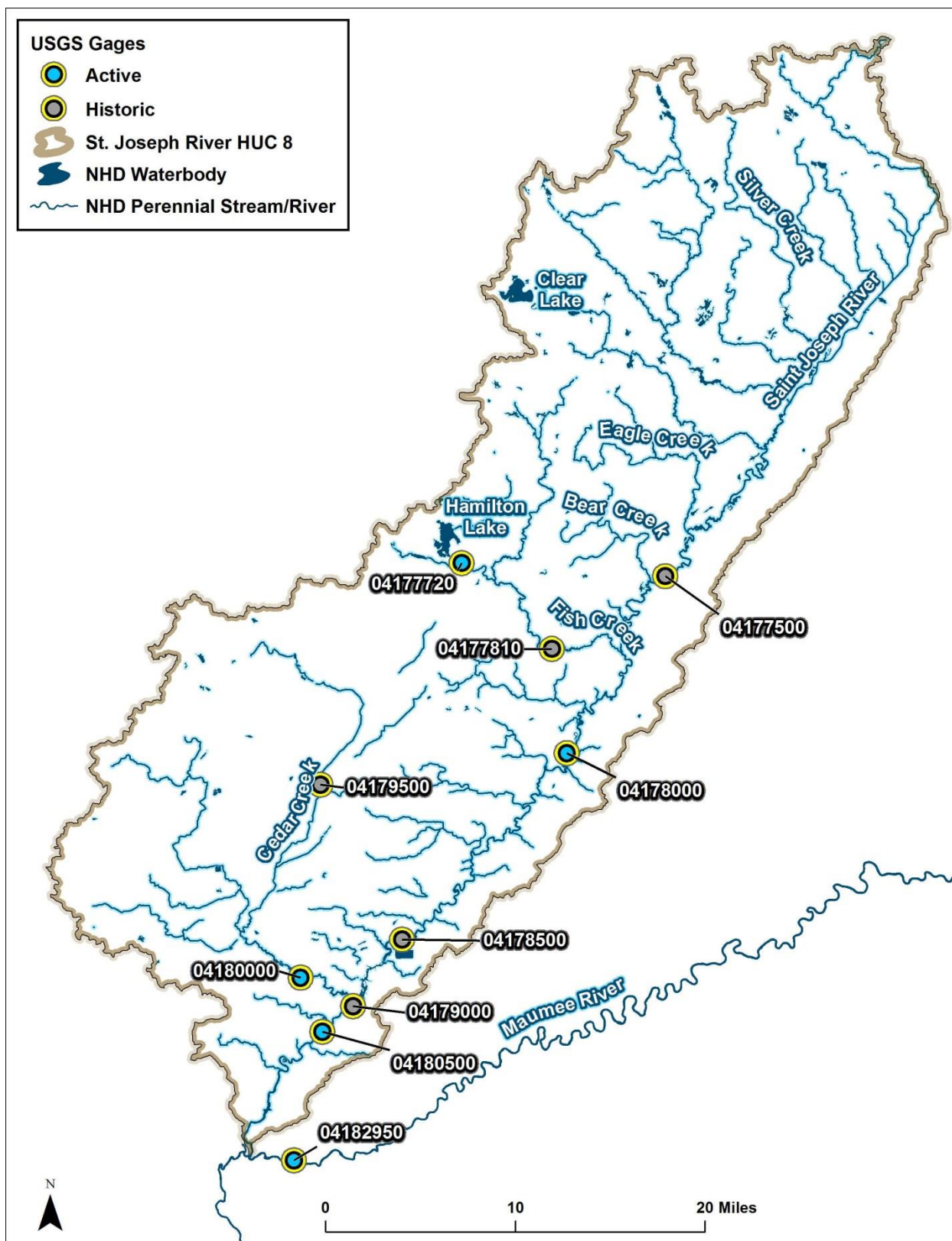


Figure 14. Continuously-recording streamflow USGS gages in the SJRW.

3.8 Community Profile

The SJRW spans three states and is predominantly rural. The southern portion of the watershed is within the Fort Wayne, IN metropolitan area. Most of the basin's population is clustered in the Fort Wayne metropolitan area and small rural cities (e.g., Auburn, IN and Montpelier, OH); refer back to Figure 9 for a map that shows the largest cities in the watershed. Most of the land area of the basin has low population densities.

Population trends from 2000 to 2010 varied by county and municipality. Allen, DeKalb, Noble, and Steuben counties in Indiana increased in population, while Defiance and Williams counties in Ohio decreased in population (Table B-9 in Appendix B). Branch County in Michigan slightly increased in population and Hillsdale County slightly decreased. Most of the relatively significant population changes in the municipalities were due to a few dozen to a few hundred people because most municipalities have populations of less than 2,000 people. Fort Wayne saw an increase of nearly 48,000 people that includes increased development in the metropolitan area in the SJRW and also includes some people in Fort Wayne outside of this watershed. Urbanization is spreading north from Fort Wayne and along the transportation corridors in DeKalb and Steuben counties" (SJRWI 2006, p. 7).

While this project does not explicitly address public drinking water supply designated uses or groundwater quality (as related to potable water usage), watershed stakeholders are concerned with the quality of surface- and groundwater (SJRWI 2006, 2008; Quandt nd, 2015). The SJR is a public "drinking water supply for 250,000 people in Fort Wayne and New Haven" and the "Fort Wayne Three Rivers Filtration Plant processes 34 million gallons" of water per day (SJRWI 2006, p. 10). Raw water withdrawn from the SJR is stored in two reservoirs in the Bear Creek subwatershed: Cedarville and Hurshtown reservoirs²². Adjacent areas "are served by private wells or water companies that extract water from wells" (SJRWI 2008, p. 15). Nineteen public water systems in Ohio use wells to withdraw groundwater (Ohio EPA 2015a, p. 15). About 14.9 mgd of groundwater is withdrawn daily in the SJRW for a variety of uses (e.g., drinking water, industrial, agricultural) (Quandt 2015, p. 26). TMDLs were not developed to address public drinking water uses; however, the water quality improvement strategy and TMDL implementation framework discussed in Section 7.3.2 will also help the SJRWI and stakeholders address issues related to surface- and groundwater used for potable water.

²² Cedarville and Hurshtown reservoirs have surface areas of 408 acres and 265 acres (respectively and maximum depths of 22 feet and 35 feet (respectively). The reservoirs have a combined storage of one billion gallons (SJRWI 2006, p. 10).

3.9 Species of Concern

The SJRW is home to abundant aquatic life that includes endangered and threatened riverine species. Multiple organizations survey aquatic life in the project area. For example, The Nature Conservancy operates the upper SJRW project that has identified 43 species of fish and 31 species of mussels in Fish Creek (SJRWI 2006).

Three freshwater bivalve mussel species are listed as endangered on the U.S. FWS Endangered Species List (Table 9). “Fish Creek supports the last known population of the white cat’s paw pearly mussel in the world” (SJRWI 2006, p. 15). Additional freshwater mussel species that are listed by the states as endangered or of special concern are the kidneyshell (*Ptychobranhus fasciolaris*) and purple lilliput (*Toxolasma lividus*) mussels (Table 9). SJRWI (2006) also presents the results of other studies that identified diverse species of freshwater mussels in the SJR and Cedar Creek.

Table 9. Endangered mussel species in the SJRW

Freshwater bivalve mussel species		List of species			
Common name	Scientific name	Federal	Indiana	Michigan	Ohio
clubshell	<i>Pleurobema clava</i>	E	E	E	E
kidneyshell	<i>Ptychobranhus fasciolaris</i>	--	SC	SC	SC
northern rifleshell	<i>Epioblasma torulosa</i>	E	--	E	E
purple lilliput	<i>Toxolasma lividus</i>	--	--	E	E
rabbitsfoot	<i>Quadrula cylindrical</i>	T	E	--	E
rayed bean shell	<i>Villosa fabalis</i>	--	SC	E	E
round hickory nut	<i>Obovaria subrotunda</i>	--	SC	--	--
white cats paw pearly	<i>Epioblasma obliquata</i>	E	E	E	E
wavyrayed lampmussel	<i>Lampsilis fasciola</i>	--	SC	T	SC

Sources: Michigan DEQ 2015c; ODNR 2014; Ohio EPA 1994, p. 9; SJRWI 2006, p. 16; SJRWI 2008, p. 55.

Note: E = endangered; SC = special concern, T = threatened.

Two snake species that reside in wetlands and floodplain habitats are the copperbelly water snake (*Nerodia erythrogaster*) and eastern massasauga (*Sistrurus c. catenatus*; Quandt nd); both of these species are endangered in Ohio, the eastern massasauga is endangered in Indiana, and the eastern massasauga is also considered as a special concern species in Michigan. The copperbelly water snake is federally threatened (ODNR 2014). The copperbelly water snake was identified in the East Fork of the West Branch of the St. Joseph River (SJRWI 2006, p. 61).

Quandt (nd) and SJRWI 2006, 2008) present additional plant and animal species that are threatened or endangered according to the U.S. FWS or are species that are of concern, of interest, threatened, potentially threatened, or endangered according to the state governments. Some of these species may live in or otherwise use stream or stream-adjacent habitat. For example, the snail campeloma (*Campeloma decisum*) is a species of concern in Indiana that was identified in the SJR (SJRWI 2008, p. 55) and bald eagles (*Haliaeetus leucocephalus*) and are considered as a special concern species in Michigan.

4 Source Assessment

Source assessments are an important component of water quality management plans and TMDL development. These analyses are generally used to evaluate the type, magnitude, timing, and location of pollutant loading to a waterbody (U.S. EPA 1999). Source assessment methods vary widely with respect to their applicability, ease of use, and acceptability. The purpose of this section is to identify possible sources of the pollutants of concern in the TMDL project area.

To facilitate the source assessment, sources of impairment are evaluated at the subwatershed-level. Using subwatersheds creates an opportunity for watershed managers to relate source information to water quality monitoring results and sets the stage for the TMDL linkage analysis. The ability to summarize information at different spatial scales strengthens the overall TMDL development process and enables more effective targeting of implementation efforts.

The first section below presents the pollutants of concern that cause impairments in the SJRW. The next two sections provide general information regarding point sources and nonpoint sources throughout the SJRW. The chapter continues with presentations of two methods for assessing sources: the SWAT model and load duration curves (LDCs). The impaired subwatersheds are evaluated individually in Section 5 and 6, which include SWAT model results and LDC analyses.

4.1 Pollutants of Concern

Pollutants of concern discussed in this source assessment are *E. coli* bacteria, phosphorus (as total phosphorus), and TSS (a surrogate for sedimentation/siltation). These pollutants can originate from an array of sources including point sources (e.g., WWTPs) and nonpoint sources (e.g. failing HSTS).

4.1.1 Bacteria

Microorganisms are ubiquitous across the world and while most are not harmful to humans, pathogens (i.e., disease causing microorganisms) are a small subset of microorganisms that can cause sickness or death when taken into the body (U.S. EPA 2001). Certain bacteria typically indicate the presence of pathogens. *E. coli* is an indicator of pathogenic bacteria and Indiana, Michigan, and Ohio have established numeric criteria for *E. coli* based upon designated RUs.

Typical point sources of pathogenic bacteria include WWTPs and CSOs (U.S. EPA 2001). Sewage that is not sufficiently treated or that bypasses wastewater treatment (e.g., CSOs) may result in elevated levels of in-stream pathogens when discharged to a surface waterbody. “Other point sources that can contribute substantial loads of pathogens and fecal indicators to waterbodies include concentrated animal feeding operations, slaughterhouses and meat processing facilities; tanning, textile, and pulp and paper factories; and fish and shellfish processing facilities” (U.S. EPA 2001, p. 2-6). Regulated stormwater may transport animal excrement deposited by pets or wildlife to nearby streams via storm sewer infrastructure following precipitation events that result in stormwater runoff. Point sources in the SJRW include WWTPs, CSOs, SSOs, CAFOs, pets and wildlife via regulated stormwater, and illicit sanitary connections to storm sewers.

Nonpoint sources of pathogens can be residential (e.g., HSTS, pets), agricultural (e.g., livestock, manure application to crops fields), and natural (e.g., wildlife). HSTS that are not functioning properly may discharge untreated sewage to downstream waterbodies. Pet excrement deposited in residential areas, wildlife excrement deposited in rural areas, livestock excrement deposited on pastures and barnyards, and manure or septage applied to crop fields or stored improperly may be transported to streams after precipitation events that result in stormwater runoff. Nonpoint sources that may discharge *E. coli* in the

SJRW include failing HSTS, non-CAFO livestock operations, wildlife, pets, and crop management (land application of WWTP sludge, septage, or manure).

Both point and nonpoint sources of pathogens can re-enter the water column through re-suspension of sediments when pathogens are attached to those sediments. Runoff will increase the velocity of water in a stream, which may yield sufficient power to scour the bottom of the stream.

Regardless of the source, once pathogens enter surface waterbodies, in-stream pathogen levels decrease over time. The die-off is controlled by factors including: sunlight, temperature, moisture conditions, and salinity (U.S. EPA 2001, p. 2-7). In-stream pathogen levels are dependent upon the die-off rate and the time and distance from the source to the waterbody of interest.

4.1.2 Nutrients

This section presents discussions of the nutrient phosphorus and concludes with a discussion of limiting nutrients.

4.1.2.1 Phosphorus

At some level, phosphorus is necessary in a waterbody to sustain aquatic life. The natural amount of phosphorus in a waterbody varies depending on the type of system. A pristine mountain spring might have little to almost no phosphorus, whereas a lowland, mature stream flowing through wetland areas might have naturally high concentrations. As previously mentioned, phosphorus can be released into the environment through different anthropogenic sources including septic systems, WWTPs, fertilizer application, and livestock operations. Once released into the environment, phosphorus generally attaches to soil particles and organic matter and is transported with eroded sediments (U.S. EPA 1999).

Phosphorus, like other nutrients, rarely approaches concentrations in the ambient environment that negatively affect aquatic life; in fact, nutrients are essential in minute amounts for properly functioning, healthy, aquatic ecosystems. However, nutrient concentrations in excess of those minute needs can exert negative effects on the aquatic ecosystem by increasing algal and aquatic plant life production (Sharpley et al. 1994). Increased plant production increases turbidity, decreases average dissolved oxygen concentrations, and increases fluctuations in diurnal dissolved oxygen and pH levels. Such changes shift aquatic species composition away from functional assemblages (composed of intolerant species, benthic insectivores, and top carnivores that are typical of high-quality streams) toward less desirable assemblages of tolerant species, generalists, omnivores, and detritivores that are typical of degraded streams (Ohio EPA 1999). Such a shift in community structure lowers the diversity of the system.

In its evaluation of biological data for reference (i.e., least-affected) streams, Ohio EPA found that IBI and ICI scores do not meet the WWH biocriteria when associated with higher levels of total phosphorus, (Ohio EPA 1999, p. 26). Ohio EPA further concludes that “[t]he processing of nutrients in lotic ecosystems²³ is complex, variable, and affected by abiotic factors such as flow, gradient, ground water quality and quantity, and channel morphology” (Ohio EPA 1999, p.10). In the HELP ecoregion, Ohio EPA (1999, p. 27) finds that low gradient headwaters and wading streams (similar to those in the project area) had higher total phosphorus concentrations than higher gradient streams. An in-depth summary of the effects of nutrients on aquatic life and the interrelationships of water quality, habitat, and biota are presented in the *Associations* document (Ohio EPA 1999).

Typical sources of total phosphorus are human and animal waste, fertilizer application to agricultural crops and urban lawns/gardens, erosion in stream channels, wetlands, and re-suspension of phosphorus bound to sediment from an upstream source. In an analysis of total phosphorus export coefficients from

²³ Lotic refers to flowing water; thus, a lotic ecosystem consists of the biological communities and non-living components of a stream or river.

various studies, Lin (2004) found that feedlots and manure storage yield the largest unit area loads and forestland yields the smallest loads. The ranked land uses are as follows (Lin 2004, Tables 1 and 3):

- Feed lots and manure storage (largest total phosphorus export coefficients)
- Residential
- Industrial
- Row crop agriculture
- Non-row crop agriculture, pasture, and mixed agriculture
- Idle land
- Forest (smallest total phosphorus export coefficients)

It is expected that the results of Lin (2004) would be consistent with the SJRW, which is largely a rural, agricultural watershed. As discussed later in this chapter, there are few large animal operations in the basin and industrial and municipal point sources are limited to a few cities and larger villages.

Agricultural activities are expected to contribute the largest relative total phosphorus loads throughout the SJRW, except in subwatersheds with cities and un-sewered towns.

4.1.2.2 Limiting Nutrient

TP is the surrogate pollutant used to represent Indiana's nutrient and IBC listings (IDEM 2014c) and Ohio's nutrient impairments in the SJRW. In addition to phosphorus species, nitrogen species are also important nutrients that can cause impairment to aquatic life. Since IDEM uses TP as a surrogate pollutant for TMDLs to address nutrient impairments and Ohio EPA uses a limiting nutrient analysis (phosphorus is the limiting nutrient in the SJRW), nitrogen species are not discussed in this report. However, many of the sources of nitrogen are also sources of phosphorus (e.g., crop management, livestock operations, WWTPs, HSTS); thus, some of the implementation strategies employed by the SJRW nutrient TMDLs will also address some of the sources of nitrogen. For discussions of phosphorus and nitrogen species and nutrient impairments, refer to Camargo et al. (2005), Eby (2004), Ohio EPA (1999), Spiro and Stigliani (2003), U.S. EPA (1999, 2000).

Ohio EPA uses limiting nutrient analyses to determine whether nitrogen or phosphorus TMDLs should be developed (e.g., Ohio EPA 2012c). In such analyses, the molar concentrations of phosphorus and nitrogen species are compared and different ranges of the ratio of phosphorus species to nitrogen species indicate the limiting nutrient.

Ohio EPA prefers to use a ratio of TP to total nitrogen (TN), although in some cases Ohio EPA has used a ratio of total inorganic nitrogen to total phosphorus (Ohio EPA 2012c) due to the lack of total Kjeldahl nitrogen data to calculate TN. Ratios of other nutrient species have been used elsewhere; for example, nitrate to phosphate (Schanz and Juon 1983) and dissolved inorganic nitrogen to soluble reactive phosphorus (Stelzer and Lamberti 2001).

Ohio EPA uses a threshold ratio of 16:1, which is the Redfield ratio, to determine which nutrient is limiting. Ratios less than 16:1 indicate nitrogen-limitation while ratios greater than 16:1 indicate phosphorus-limitation. The threshold ratio varies considerably throughout the literature:

- Bioassays using periphyton from the River Rhine, found that algal growth in the bioassays was limited by nitrogen at nitrate:phosphate ratios of less than 10:1 and by phosphorus at ratios greater than 20:1 (Schanz and Juon 1983).

- Nutrient amendment experiments in New Zealand gravel bed streams found that nitrogen-limitation and co-limitation occurred over wide ranges of ratios and that phosphorus-limitation occurred around a ratio of 30:1 (Francoeur et al. 1999).
- Stelzer and Lamberti (2001) found that bio-volume was not affected by the ratio of dissolved inorganic nitrogen to soluble reactive phosphorus and that predicting nutrient limitation from stream water has limitations.
- A review of 382 nutrient enrichment experiments showed that the ratio of nitrogen to phosphorus was good at predicting whether or not nitrogen was the limiting nutrient but that predictions were uncertain between ratios of 1:1 and 100:1 (Keck and Lepori 2012).

All of the paired TP and TN concentrations from samples collected along an impaired stream were evaluated with the 16:1 ratio. Ohio EPA decided that when all or most of the ratios of TP:TN for an impaired stream were greater than the 16:1 ratio, a stream was assumed to be phosphorus-limited or co-limited and that a TP TMDL should then be developed. Most of the samples from Ohio's impaired WAUs in the SJRW watershed exhibited ratios greater than 16:1. Thus, TP was selected as the surrogate pollutant for TMDL development for Ohio's TMDLs.

4.1.3 Sedimentation/Siltation

Sedimentation and siltation are controlled by stream hydrology, channel condition, riparian areas, and watershed land use. Impairment occurs when external inputs (e.g., sediment, runoff volume) to the stream become excessive, or when stream characteristics are altered so that the stream can no longer assimilate these stresses, or a combination of both.

Streams with high flows can result in channel scour and erosion of the stream channel. Those streams are also able to transport larger sediment particles further distances. Streams that are dominated by lower flow conditions will deposit sediment and associated pollutants resulting in poor quality habitat and loss of spawning beds. In addition, low flowing streams will have lower dissolved oxygen levels. A stream's assimilative capacity for pollutant loads from the watershed will depend on its ability to balance all those factors.

Hydrology is a major driver for both upland and stream channel erosion and agricultural activities can also alter the hydrologic regime, channel condition, and riparian areas. Agricultural activities such as livestock grazing and the plowing or tilling of crop fields result in de-vegetated, exposed soil that is susceptible to erosion (U.S. EPA 2012a). "Conventional tillage associated with row crop farming results in an accelerated loss of soil from fields, and as a consequence, sedimentation of stream channels" (Myers et al. p. 2). Drain tiles may also increase channel erosion since runoff that travels through tiles has increased peak flows and velocities, both of which increase erosion. Runoff transported by tiles may have higher concentrations of suspended sediment, which may then be deposited (i.e., settle) in the streams or ditches, and thus contribute to sedimentation and habitat issues.

As much of the SJRW is rural and agricultural, urbanization impacts hydrology in only isolated locations. Urban streams tend to drain impervious surfaces that alter the hydrologic regime (e.g., higher magnitude flows, more frequent high flows), which then increases the erosion of the streambed and banks and increases re-suspension of bed sediment (U.S. EPA 2012a). For additional information regarding urban and impervious cover impacts upon hydrology that affect sedimentation, siltation, erosion, and such, refer to Schueler (1995) and Shaver et al. (2007).

Channelized streams are present throughout the project area. Streams are channelized to purposefully direct and control flow in agricultural areas, and to a lesser extent in the SJRW, in urbanized areas. Channelization results in higher peak flows that travel more rapidly; these more powerful flows have

greater capacity to erode the channels banks and can carry more sediment farther. The effects of channelization with regards to erosion and sedimentation are presented in Section 4.3.8.

Typical sources of sediment derived from in-stream processes include: incised channels, channel modification, and eroding and collapsing stream banks (U.S. EPA 2012a). Sediment is also derived from eroding soil from anthropogenic activities in both agricultural areas (e.g., livestock grazing, plowing) and urban areas (e.g., construction, roads) and eroding soil from natural processes (e.g., landslides, burnt forests) (U.S. EPA 2012a).

4.2 Point Sources

Point source pollution is defined by CWA section 502(14) as, “any discernible, confined and discrete conveyance, including any ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation [CAFO], or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agriculture stormwater discharges and return flow from irrigated agriculture.”

Point sources can include facilities such as municipal WWTPs, industrial facilities, CAFOs, or regulated stormwater, including MS4s. Under the CWA, all point sources are regulated under the National Pollutant Discharge Elimination System (NPDES) program. NPDES permit holders in the SJRW are discussed below.

4.2.1 Industrial Facilities with Individual NPDES Permits

Forty-two facilities hold individual NPDES permits in the SJRW and 18 permittees are industrial or privately owned. Refer to Table C-1, Table C-2, and Table C-3 in Appendix C for a list of individual NPDES permits in Michigan, Ohio, and Indiana. Maps of these facilities are provided in Figure C-1, Figure C-2, and Figure C-3 for Michigan, Ohio, and Indiana, respectively.

4.2.2 Public Facilities with Individual NPDES Permits

Twenty-five public facilities hold individual NPDES permits in the SJRW, including three communities with combined sewer systems (CSSs)²⁴. Refer to Appendix C for a list and maps of facilities with individual NPDES permits, which also includes four terminated permits in Indiana. Facilities that are permitted to discharge combined or sanitary sewer overflows or to provide sludge for land application are further evaluated in the following subsections.

4.2.2.1 Combined Sewer Systems

Four facilities are permitted to discharge CSOs in the SJRW (Table 10). These CSSs are potential sources of bacteria and nutrients that impair waterbodies in the project area. The Auburn WWTP, Butler WWTP, Fort Wayne Municipal WWTP, and Montpelier WWTP are permitted to discharge through 14 outfalls into three receiving waterbodies in the SJRW. Each CSS is briefly summarized in this section and available CSO data for Auburn (Table C-5), Butler (Table C-6), Fort Wayne (Table C-7), and Montpelier (Table C-8) are presented in Appendix C.

²⁴ The cities of Auburn and Butler are CSSs in Indiana and the village of Montpelier is a CSS in Ohio; these three CSSs are wholly within the SJRW. The city of Fort Wayne is also a CSS; however, only a portion of it is in the SJRW and many of its CSO outfalls are in the adjacent Saint Mary's watershed.

Table 10. Public individual NPDES permittees with CSSs

NPDES ID	Facility	CSO outfalls in the SJRW	Receiving waterbody	HU (04100011)
IN0020672	Auburn WWTP	002, 007, 009, 010	Cedar Creek	06 04
IN0022462	Butler WWTP	003	Big Run	05 02
IN0032191	Fort Wayne Municipal WWTP	044, 045, 051, 052, 053, 068	St. Joseph River ^a	08 06
OH0021831	Montpelier WWTP	003, 004, 006	St. Joseph River	03 04

Sources: IDEM 2015, Ohio EPA 2015a,b,c.

Notes

CSO = combined sewer overflow; HU = hydrologic unit; WWTP = wastewater treatment plant.

a. The Fort Wayne combined sewer system discharges to eight waterbodies, including the St. Joseph River.

Auburn

The Auburn WWTP is a 4.5 mgd facility composed of two separate plants that discharge treated effluent to Cedar Creek (Auburn 2011). The CSS has four CSO outfalls, with three outfalls on Cedar Creek and one outfall on John Diehl Ditch (IDEM 2010). Outfall 011 is an outfall for a Wet Weather Storage/Treatment Facility which discharges to Cedar Creek. In addition, CSO 002 is only identified as an emergency CSO and exists for emergency purposes only (IDEM 2015, p. 2, Permit). The LTCP is approved to address the remaining CSOs by approximately 2028.

Butler

The Butler WWTP is 3 mgd and serves about 2,700 people (Rice 2005). “The WWTP processes about 800,000 gallons of wastewater per day, with 500,000 gallons/day coming from industrial areas,” with industrial pretreatment (Rice 2005, p. 40). Butler has a CSO treatment facility (Outfall 001) that discharges into Big Run Creek. CSO 003 is currently active and according to the LTCP will only discharge under certain conditions.

Fort Wayne

The P.L. Brunner Water Pollution Control Facility (hereafter, Fort Wayne Municipal WWTP) is a 60 mgd conventional activated sludge WWTP that discharges treated effluent to the Maumee River. Upgrades to the Fort Wayne WWTP have allowed treatment for wet weather flows of up to 100 MGD. Fort Wayne is implementing a LTCP that was approved by IDEM and U.S. EPA as part of *Federal Consent Decree in Civil Action No. 2:07cv 00445* (IDEM 2011). This consent decree was further modified on January 26, 2015 which eliminated satellite disinfection or satellite storage and treatment as the control measures for City CSOs discharging to the St. Joseph River, and replaced those control measures with a plan to install relieve sewers. The agreed upon 18 year implementation schedule for the LTCP allows the city to construct CSO control measures in a planned and orderly fashion. The St. Joseph River controls will be fully implemented by 2019, Maumee River controls by 2022, and St. Mary’s River by 2025. The Fort Wayne CSS discharges through 41 CSO outfalls to the following eight waterbodies:

- Baldwin Ditch (3)
- Maumee River (7)
- Natural Drain #4 (1)
- Spy Run Creek (1)
- SJR (6)
- St. Mary’s River (19)
- Unnamed ditch to the Maumee River (2)
- Wigman Drain (1).

Montpelier

The Montpelier WWTP serves the village of Montpelier, two small trailer parks (35 units totaling 5,000 gallons per day [gpd]), a middle school (2,000 gpd), and the Enrichment Center (500 gpd; Jones & Henry Engineers, Ltd. 2006). Portions of the service area are a CSS. All lateral and main line sewers discharge to two trunk lines that connect to an interceptor. CSO structures are at each junction of the interceptor with the trunk lines (Washington Street CSO and Randolph Street CSO) and at the pump that connects the interceptor with the WWTP (Randolph Street Pumping Station CSO). A map of the sewer system and specifications for each component of the WWTP are presented in the LTCP (Jones & Henry Engineers, Ltd. 2006).

The village of Montpelier is implementing a LTCP that calls for complete separation of storm and sanitary sewers (Jones & Henry Engineers, Ltd. 2006). The village is installing new gravity sanitary sewer lines and the existing combined sewer lines will become stormwater lines. Montpelier first began to evaluate separating its sewers in 1962 and completed 17 major sewer projects from 1988 through 2004 (Jones & Henry Engineers, Ltd. 2006, p. 3). The LTCP, as revised, calls for six phases of separation that should be completed by 2026. The LTCP assumed nearly stagnant population growth; however, the village population shrunk between the years 2000 and 2010 (Table B-9 in Appendix B). Presently, about 43 percent of the inflow to the secondary WWTP is estimated to be infiltration and inflow, with residential, commercial, and industrial inflows estimated to be 26, 7, and 24 percent, respectively). Once implemented, the infiltration and inflow is expected to be less than one-third of the WWTP inflow; due to the lack of growth, the daily average inflow was assumed to decrease as the infiltration and inflow decreases. The significant population decline in the late 2000s was not anticipated in the LTCP.

4.2.2.2 Sanitary Sewer Systems with Overflows

NPDES permits prohibit SSOs and require all SSOs to be reported to appropriate government agencies. In general, TMDLs require all NPDES permittees to fully comply with their NPDES permits; therefore, WLAs are not allocated to SSOs. If SSOs contribute to impairments, they are addressed by U.S. EPA and the state agencies through the NPDES program. A brief summary of documented SSOs in the SJRW is presented herein. No SSOs were reported at public facilities in Michigan²⁵.

Ohio EPA has documented SSOs at four of the public facilities with individual NPDES permits in the SJRW: Edgerton WWTP (2PB00047), Montpelier WWTP (2PD00003), Pioneer WWTP (2PB00006), and Edon WWTP (2PA00031). No SSOs were reported at the Edgerton or Edon WWTPs in the past decade (Ohio EPA 2015a). DMR data are summarized in Table C-9 of Appendix C.

The elimination of SSOs is included as part of Fort Wayne's LTCP. The Fort Wayne Municipal WWTP has four SSO outfalls in *Ely Run-St. Joseph River* (04100011 08 05): 072, 074, 075, and 076). These SSO outfalls are part of the Rothman System, and through infrastructure improvements, the SSOs will be eliminated (Fort Wayne 2007, Appendix 5).

4.2.2.3 Biosolids Application Fields

Biosolids, similar to livestock manure and HSTS septage, are applied as a fertilizer to crop fields. In the SJRW, biosolids are applied to four fields in Michigan, seven fields in Ohio (Figure C-2), and 117 fields in Indiana (Figure C-3). Refer to Tables C-10 and C-11 for a list of public facilities with individual NPDES permits that apply their sludge to agricultural fields. WWTP sludge is land applied to four fields in Michigan, and three of those fields receive sludge from WWTPs outside of the SJRW. Conversely, Montpelier WWTP is the only WWTP that supplies sludge to farmers in Ohio for land application in the SJRW. Six facilities in Indiana apply WWTP sludge to 64 fields: Auburn

²⁵ Aaron Parker, Michigan DEQ, personal communication (via electronic mail), February 23, 2015.

WWTP (35 fields), Beatrice Cheese Company (5), Garrett WWTP (6), Hamilton Conservancy District (2), Pickle Properties, LLC (4), Steel Dynamics Inc. (5), and Waterloo Municipal Sewage Treatment Plant (STP; 7). The remaining 53 fields in Indiana receive WWTP sludge from facilities outside of the SJRW. IDEM allows facilities to market their biosolids, therefore it is possible that additional biosolids may be applied to land within the SJRW.

4.2.3 Concentrated Animal Feeding Operation covered by NPDES Permits

Six CAFOs are in the SJRW, in Indiana and Michigan (Table 11). Michigan DEQ issues general and individual NPDES permits for CAFOs, Ohio EPA issues individual NPDES permits for CAFOs, while IDEM issues individual NPDES permits. Michigan DEQ (2004, 2010)²⁶ general NPDES permits prohibit discharges (1) during dry weather, (2) during wet weather when control structures are overflowed, washed out, or collapsed, (3) that cause surface waters to violate Michigan WQS, and (4) to groundwater. CAFO general permittees must develop nutrient management plans, and construct control structures and measures to contain 6-months of CAFO waste and production area runoff from a 25-year, 24-hour storm event. All CFOs in Indiana must obtain either a CFO permit or NPDES CAFO permit. For CFOs (regardless of size) that do not discharge manure- or pollutant-bearing water to Indiana surface waters, IDEM issues *CFO Approval*. For CFOs (regardless of size) that discharge manure- or pollutant-bearing water to Indiana surface waters, IDEM issues individual NPDES permits; IDEM issues such permit coverage to non-CAFO-sized CFOs and CAFOs. The discharge of process water is only allowed during certain storm events, and should not result in a violation of water quality standards. See 327 IAC 15-16-7 (d), (e) and (f). IDEM issued individual NPDES permits are more stringent than U.S. EPA CAFO rules, and IDEM permits prohibit discharges of manure, process wastewater, and contaminated stormwater to streams and rivers (IDEM 2012). Michigan's general NPDES permit and Indiana's individual NPDES permits also limit land application of CAFO waste (e.g., application rates, prohibition of application to flooded fields, stream setbacks).

Table 11. CAFOs in the SJRW

NPDES ID	Facility	Animal units	HU (04100011)
Michigan			
MIG010057	Triple T Farms	4,000 hogs	03 02
Ohio			
none			
Indiana			
--	Irish Acres Dairy LLC	2,300 dairy cattle	05 02
--	Phillips Farm	170 dairy calves 1,950 dairy heifers	06 01
--	Sunrise Heifer Farms LLC	2,650 dairy heifers	07 02
--	Mark S. Rekeweg	7,000 finishers 1,100 nursery pigs	08 02
--	Laub Farm LLC	3,600 finishers 2,900 nursery pigs 750 sows	08 02

Sources: IDEM (2014a, 2015a) and Michigan DEQ (2007).

Note: CAFO = concentrated animal feeding operation; HU = hydrologic unit; SJRW = St. Joseph River watershed.

²⁶ Michigan DEQ (2004) issued a general NPDES permit for new large CAFOs (MIG010000) that was effective June 11, 2004 and expired April 1, 2009, and Michigan DEQ (2010) issued a new general permit (MIG019000) that was effective April 1, 2010 and expired April 1, 2015.

Triple T Farms CAFO wastewater is land applied to about 570 acres of crop fields in Camden and Reading townships of Hillsdale County; an estimated 400 acres are in the SJRW. See the map in Figure C-1 for approximate locations of land application sites in the SJRW.

Indiana's five CAFOs are prohibited from discharging to surface waters. Indiana CAFO waste must be fully contained at their on-site storage structures. CAFO manure and process water can be land-applied to crop fields, under regulated circumstances (IDEM 2012); however, land application is not tracked and locations of land application are not available for mapping.

A single concentrated animal feeding facility (CAFF) is in Ohio and eight confined feeding operations (CFOs) are in Indiana. These operations are not regulated through the NPDES program, nor will they receive WLAs within this TMDL framework. See Section 4.3.6 for discussions of non-CAFO animal facilities.

4.2.4 Facilities Covered by General NPDES Permits (Non-Stormwater, Non-HSTS)

Sixteen facilities hold general NPDES permits in the SJRW for non-stormwater, non-HSTS discharges. Refer to Appendix C for a list of public facilities with general NPDES permits, which also includes one terminated permit in Indiana. Six types of general NPDES permittees (non-stormwater, non-HSTS) are in the SJRW:

- Dimension stone and crushed stone operation (1) in Indiana
- Groundwater petroleum remediation system (1) in Indiana
- Non-contact cooling water systems in Indiana (4), Michigan (1), and Ohio (1)
- Petroleum product terminal (1) in Indiana
- Public swimming pool (1) in Michigan
- Wastewater stabilization lagoons (8) in Michigan

Only the wastewater stabilization lagoons (WWSLs) are pertinent to this TMDL study. None of the other types of general permits allow the discharge of bacteria or nutrients (IDEM 2014b; Michigan DEQ 2009, 2012, 2014a; Ohio EPA 2010a,b). Except for the dimension stone and crushed stone operation general permittee, none of the general permits allow for the discharge of TSS.

Michigan DEQ issues general NPDES permits for WWSL effluent (MIG58000). WWSLs seasonally discharge sanitary or municipal wastewater that is treated in stabilization lagoons (Michigan DEQ 2014a). Discharges are only permitted in the spring and fall²⁷ and each discharge event requires pre-approval from Michigan DEQ; discharges may not exceed a duration of 10-days within a 14-day period. The general permit includes fecal coliform and TSS effluent limits and Michigan DEQ may impose total phosphorus limits (Michigan DEQ 2014a). Michigan's WWSLs are further discussed, as appropriate, in the subwatershed-by-subwatershed analyses presented in linkage analyses of Section 5 and Section 6.

4.2.5 Facilities and Entities Covered by General NPDES Permits for Stormwater

Regulated stormwater runoff can be a significant source of pollutants to the SJRW. Stormwater runoff can contain bacteria, nutrients, and sediment, in addition to numerous other pollutants. Also, stormwater runoff rates and volumes can cause impacts to stream channels and habitat. The sections below present general information regarding pollutant transport in regulated stormwater (typically urban stormwater) and a summary of each state's stormwater program, including information that is specific to the project area.

²⁷ Discharges are prohibited in January, February, June, July, August, and September and when the receiving waterbody is frozen.

4.2.5.1 Urban Stormwater

The type of development and land uses generally determine the quality of and constituents in the stormwater (Shaver et al. 2007) as does the level of automobile activity (Burton and Pitt 2002). Stormwater from transportation land uses (e.g., roads, bridges, service stations) can contain petroleum hydrocarbons or copper derived from brake pads whereas stormwater derived from runoff of fertilized residential lawns, golf courses, and manicured or landscaped areas can contain elevated levels of nutrients (Shaver et al. 2007). Urban and suburban stormwater runoff characteristics typically differ considerably as compared to rural and undeveloped areas (Pitt et al. 1995; U.S. EPA 1983).

Any constituents that are deposited on impervious surfaces will typically remain there until they are picked up and transported by urban stormwater. For example, when pet waste is improperly disposed of, it can be picked up by stormwater runoff and washed into storm drains or nearby waterbodies. Since storm drains do not always connect to treatment facilities, untreated animal feces often end up in lakes and streams. In undeveloped areas, some constituents will be transported to shallow aquifers as water infiltrates. However, because infiltration cannot occur on impervious surfaces, pollutants that accumulate on impervious surfaces will be rapidly carried to surface waterbodies through runoff or stormwater conveyance systems where they can pose a risk to human and ecological health (Shaver et al. 2007; Schueler 1994).

Many toxic constituents bond to particulate matter and can be transmitted in stormwater while adsorbed to the sediment. For example, “hydrocarbons are normally attached to sediment particles or organic matter carried in urban runoff” (Shaver et al. 2007 p. 3-48). Because stormwater tends to travel rapidly over impervious surfaces, the high-velocity water has an increased “ability to detach sediment and associated pollutants, to carry them off site, and to deposit them downstream” (Burton and Pitt 2002, p. 31). The sediment and adsorbed pollutants can accumulate in bottom sediments “where they are readily available to aquatic organisms and possible re-suspension during future storm events” (Masterson and Bannerman 1994, p. 131). Sedimentation can increase in downstream ponds or slower-moving streams when sediment-laden, high-velocity stormwater discharges to the waterbodies.

Pitt et al. (1996, p.4) evaluated urban stormwater and found that metals were typically detected in high concentrations. Masterson and Bannerman (1994) generally found that heavy metal concentrations in urban streams in Wisconsin exceeded the concentrations in reference streams. Stress and lethality to aquatic organisms can occur from episodic exposure to stormwater laden with metals (Burton and Pitt 2002, p. 77). The typical sources of nutrients (e.g., nitrates and phosphates) in urban runoff include fertilizer runoff from lawns, landscaped areas, and golf courses (Shaver et al. 2007, p. 3-47). Bacteria sources include pet and wildlife waste that are transported via runoff from a precipitation event to storm sewers and streams; illicit connections to the storm sewers are also a potential source of bacteria since the domestic waste from the illicit connection does not get treated. Typical sources of sediment in urban stormwater include bank erosion, which increases due to faster and more powerful stream flows caused by urban development, and runoff from construction or industrial sites that is not properly contained (e.g., silt fences) and treated (e.g., settling pond).

4.2.5.2 Regulated Municipal Separate Storm Sewer System

Regulated MS4 programs vary by state but must follow rules and guidelines established by U.S. EPA. Specifically, regulated MS4s must implement six minimum control measures, which are public education, public involvement, illicit discharge detection and elimination programs, control of construction site runoff, post-construction stormwater management in new development and redevelopment, and pollution prevention/good housekeeping for municipal operations. In urban areas, the cross-connection of sanitary and storm sewer lines are issues for both WWTPs and MS4s. State NPDES programs require both WWTPs and regulated MS4s to identify and eliminate illicit discharges due to cross-connections.

4.2.5.3 Michigan's Stormwater Program

Michigan DEQ regulates stormwater through its NPDES program²⁸. No regulated MS4s or industrial facilities that discharge stormwater are in the SJRW in Michigan; construction sites regulated under a general permit may have been in the SJRW.

From 2001 through 2014, 27 construction sites in Hillsdale County were covered under Michigan's general NPDES permit for stormwater from construction sites (Michigan DEQ 2015b). There are 9 townships in southern Hillsdale County that are at least partially in the SJRW, and 11 construction sites with permit coverage are in these townships. As most of Michigan's sources of regulated stormwater are not in the SJRW, and only a few expired and terminated construction site permit coverages have the potential to be in the SJRW, Michigan's stormwater program is not further discussed.

Residential and commercial properties in the rural portion of Hillsdale County in the SJRW may discharge non-regulated stormwater. Such stormwater should not contain phosphorus from lawn or turf fertilizers because Michigan prohibits such fertilizers from containing available phosphorus (P_2O_5), with certain exemptions (Michigan 2010).

4.2.5.4 Ohio's Stormwater Program

Ohio EPA regulates stormwater through various individual and general NPDES permits. No regulated MS4s or marinas are in the SJRW in Ohio. Industrial facilities and construction sites in the SJRW in Ohio are covered by individual and general NPDES permits.

The Multi-Sector General Permit, which addresses stormwater discharges associated with industrial activities (U.S. EPA ID OHR000005), is effective from January 2012 through December 2016. A *Notice of Intent* and stormwater pollution prevention plan must be submitted to Ohio EPA to receive permit coverage. If industrial activity is completely sheltered from stormwater, *No Exposure Certification* may be obtained. As of February 2015, eight facilities in the SJRW in Ohio are covered by general NPDES permits for stormwater discharges associated with industrial activities (Ohio EPA 2015c; Table C-2 in Appendix C) and 12 facilities were granted no exposure certification.

The NPDES general permit for stormwater discharges associated with small and large construction activities (U.S. EPA ID OHC000003) is effective from April 2013 through April 2018. The previous general permit for stormwater discharges associated with small and large construction activities (U.S. EPA ID OHC000002) was effective from April 2008 through April 2013. A *Notice of Intent* and stormwater pollution prevention plan must be submitted to Ohio EPA to receive permit coverage. Over 30 construction sites were issued permit coverage between 2004 and 2014 in Williams County (Ohio EPA 2015c). Construction sites ranged in size from 0.82 acre to 23 acres (average: 4.9 acres; median: 4.5 acres).

4.2.5.5 Indiana's Stormwater Program

Like Michigan and Ohio, Indiana regulates stormwater through various individual and general NPDES permits. In the SJRW, IDEM regulates stormwater from MS4s (3), industrial facilities (39), and construction sites (256) via NPDES permits.

Urban stormwater that is transported by public conveyance structures that compose an MS4 is covered by Rule 13 of Indiana's general NPDES permit rules (327 IAC 15-13) for MS4s. Agents of the MS4 entity must file a *Notice of Intent* and stormwater quality management plan with IDEM to receive permit

²⁸ Michigan DEQ issued general NPDES permits for stormwater from regulated MS4s (MIG040000 and MIG619000), from industrial facilities (MIG110000, MIG120000, MIG210000, MIG220000, MIG310000, MIG320000, MIG410000, MIG420000, MIG510000, and MIG520000), and from municipally operated industrial facilities (MIG510000 and MIG520000).

coverage. One city and two groups of municipalities and other entities have permit coverage in Indiana's portion of the SJRW (Table 12). As applicable, entities receiving general NPDES permit coverage for discharges associated with industrial activity and construction must notify the regulated MS4(s) if their stormwater is discharged to the MS4(s).

Table 12. Indiana's regulated MS4s in the SJRW

NPDES ID	Permittee or co-permittees	Regulated MS4 area
INR040029	city of Fort Wayne ^{a,b} Indiana University-Purdue University – Fort Wayne Ivy Tech State College – Northeast Indiana Institute of Technology ^c University of Saint Francis ^c	city limits within the SJRW
INR040119	city of Auburn ^b	city limits
INR040131	Allen County town of Huntertown town of Leo-Cedarville	town limits of Huntertown and Leo-Cedarville plus the <i>percent developed imperviousness</i> from the 2011 NLCD (Jin et al. 2013) less the city limits of Fort Wayne

Source: IDEM 2015b

Notes

MS4 = municipal separate storm sewer system; NLCD = National Land Cover Database; SJRW = St. Joseph River watershed.

a. Portions of Fort Wayne are outside of the SJRW.

b. Portions of these municipalities are also combined sewer systems; such portions are not part of the regulated MS4s.

c. The Indiana Institute of Technology is in Maumee River watershed, downstream of the SJRW, and the University of Saint Francis is in the St. Mary's River watershed.

Stormwater associated with industrial activity is covered by Rule 6 of Indiana's general NPDES permit rules (327 IAC 15-6) for construction activity. The proprietor, partner, or responsible officer of an industrial facility must file a *Notice of Intent* and stormwater pollution prevention plan with IDEM to receive permit coverage. IDEM issues a *Notice of Sufficiency* if the facility meets the requirements of Rule 6 and can issue a *Notice of Exemption* if the facility's industrial activities are not exposed to stormwater. A GIS analysis of industrial facility locations (IDEM 2015c) identified 39 such facilities in the SJRW; only 37 of the facilities were further evaluated due to plotting errors with two facilities.

Stormwater associated with construction site and land disturbance is covered by Rule 5 of Indiana's general NPDES permit rules (327 IAC 15-5) for construction activity. Property site owners must file a *Notice of Intent* and construction plan with IDEM when the construction activity or land disturbance is greater than or equal to 1 acre. Over 250 construction sites in the SJRW were regulated under the general permit between 2004 and 2014.

4.2.6 Properties with General NPDES Permit Coverage for Off-Site Discharging HSTS

Ohio EPA grants general NPDES coverage for off-site discharging HSTS²⁹. While off-site discharging HSTS in Defiance and Williams counties are covered by the general NPDES permit (Ohio EPA 2015d), no such HSTS are in the SJRW³⁰. Since no HSTS are regulated by the NPDES Program, HSTS are discussed in Section 4.3.2 in the nonpoint sources section.

²⁹ In Ohio, two general permits are issued depending on which agency determines HSTS eligibility: Ohio EPA (OHL00002; OHL00001 is expired) or local boards of health (OHK00002; OHK00001 is expired). Permit coverage is only granted to discharging systems when a residence cannot be served by an onsite soil adsorption system or by sanitary sewers. Permit coverage is granted for new and replacement systems; existing systems do not have to apply for permits.

³⁰ The street addresses of off-site discharging HSTS, available from Ohio EPA (2015d), were geocoded and plotted in GIS. Geocoded address are approximate; however, as no geocoded addressed plotted near the SJRW, it is assumed that none are in the SJRW.

4.3 Nonpoint Sources

The term *nonpoint source pollution* is defined as any source of pollution that does not meet the legal definition of point sources. Nonpoint source pollution typically results from stormwater runoff and background conditions. Note that stormwater collected and conveyed through a regulated MS4 is considered a point source. Since agricultural practices such as crop cultivation (52 percent) and pasture/hay (17 percent) cover an estimated 69 percent of the land area in the SJRW, nonpoint source pollution can contribute a significant amount of the total pollutant load. In addition to runoff and erosion, significant nonpoint sources also include home sewage treatment systems and animals.

4.3.1 Stormwater Runoff (Non-Regulated)

During wet-weather events (snowmelt and rainfall), pollutants are incorporated into runoff and can be delivered to downstream waterbodies. The resultant pollutant loads are linked to the land uses and practices in the watershed. Agricultural and developed areas can have significant effects on water quality if proper best management practices are not in place. The main pollutants of concern associated with agricultural runoff are sediment, nutrients, pesticides, and bacteria. Stormwater from developed areas can be contaminated with oil, grease, chlorides, pesticides, herbicides, nutrients, viruses, bacteria, metals, and sediment. In urban areas, some connections to storm sewers are illicit, which includes residences and businesses that discharge untreated wastewater to the storm sewers.

In addition to pollutants, alterations to a watershed's hydrology as a result of land use changes can detrimentally affect habitat and biological health. Imperviousness associated with developed land uses and agricultural field tiling can result in increased peak flows and runoff volumes and decreased base flow as a result of reduced ground water discharge. The increased peak flows and runoff volumes tend to increase streambank erosion. These more powerful flows have more capacity to move larger sediment particles farther, which may result in downstream sedimentation when the in-stream flow decreases. Drain tiles also transport agricultural runoff directly to ditches and streams, whereas runoff flowing over the land surface may infiltrate to the subsurface and may flow through vegetated riparian areas. Thus, runoff transported through drain tiles will contain all of the pollutants that it contained when the runoff entered the tile system; surficial runoff may lose pollutants as it is filtered during infiltration and passes through the vegetated riparian corridor.

For a general review of the effects of urbanization and stormwater and references to additional resources, see the *CADDIS Urbanization Module* (U.S. EPA 2012a) and *The Importance of Imperviousness* (Schueler 1994). Regulated stormwater sources are discussed in Section 4.2.5. Sources of pollutants in non-regulated stormwater are discussed in the sections below.

4.3.2 On-Site Wastewater Treatment Systems

On-site wastewater treatment systems (OWTS) treat sanitary waste and are common in rural areas without sanitary sewer systems and WWTPs. While the Fort Wayne, IN metropolitan area and small cities and villages in Indiana and Ohio are served by public sewers, many small rural communities rely on OWTS. Such communities include Blakeslee, OH, Frontier, MI, and Newville, IN.

“In the modern era, the typical onsite system has consisted primarily of a septic tank and a soil absorption field, also known as a subsurface wastewater infiltration system” (U.S. EPA 2002, p. 1-1). HSTS are a subset of OWTS that treat domestic sanitary waste for one or a few homes; larger OWTS treat clusters of homes or businesses. Hereafter, an HSTS is identified in this report as an *on-lot HSTS* if it uses a septic tank and the septic tank effluent discharges to a (1) a soil absorption field, (2) filter bed system, (3) mound system, or (4) drip distribution system. An HSTS that uses an aeration system that discharges through a pipe outlet to a surface waterbody, like any other point source, is identified as an *off-site discharging HSTS* in this report.

OWTS and HSTS are typically considered nonpoint sources of pollution; however, a subset of HSTS in Ohio are considered point sources and are regulated by Ohio's NPDES program. Ohio EPA issues general NPDES permits for new or replacement HSTS that discharge to waters of the state.³¹

This section includes discussions of general OWTS information (Section 4.3.2.1), and HSTS information specific to Michigan (Section 4.3.2.2), Ohio (Section 0), and Indiana (Section 4.3.2.4). Land application and disposal of septage are presented in the next section (Section 4.3.4).

Types of HSTS

Conventional, *on-lot* HSTS are composed of a septic tank and a subsurface wastewater infiltration system (i.e., absorption field).

Off-site discharging HSTS discharge through a pipe to a surface stream after treatment in the aeration tank.

4.3.2.1 Background

OWTS that are properly designed and maintained should not serve as a source of contamination to surface waters. However, onsite systems do fail for a variety of reasons. Common soil-type limitations that contribute to failure are seasonal water tables, compact glacial till, bedrock, coarse sand and gravel outwash and fragipan. When septic systems fail hydraulically due to surface breakouts or inadequate soil filtration, adverse effects on surface waters can result (Horsely and Witten 1996). OWTS contain all the water discharged from homes and business and can be significant sources of pathogens (e.g., bacteria) and nutrients (e.g., total phosphorus and nitrate nitrogen). Effects on surface water from OWTS are dependent on numerous factors, including soil characteristics, topography, hydrography, and their proximity to streams.

If properly designed, sited, installed, operated, and maintained, OWTS will remove suspended solids, biodegradable organic compounds, and fecal coliforms (U.S. EPA 2002, p.3-22). If OWTS do not sufficiently treat wastewater, then the following pollutants may be found in OWTS wastewater: nitrates, pathogens, and phosphorus (U.S. EPA 2002, p. 3-20). If a subsurface pollutant plume expands to the water table, then these pollutants may be transported via ground water and discharged to surface water.

TSS may also be present in OWTS effluent, though most properly working systems remove most of the TSS (e.g., TSS settles out [i.e., sedimentation occurs] in septic tanks). If too much TSS enters the system, it may clog the system and reduce infiltration. Directly discharging OWTS may contaminate surface waters as the TSS forms sludge that will detrimentally affect benthic macroinvertebrates (U.S. EPA 2002).

4.3.2.2 Michigan

Michigan regulatory code (Section 2435 of the Public Health Code, 1978 PA 368, as amended) gives local district health departments the authority to "adopt regulations to properly safeguard the public health and to prevent the spread of diseases and sources of contamination." New OWTS installations and repairs are inspected and permitted by the Branch-Hillsdale-St. Joseph Community Health Agency (BHSJ). Local health departments must be accredited by the state in a process that involves evaluation every three years.³² OWTS serving one or two homes must follow BHSJ's siting requirement while OWTS serving multiple homes or commercial structures must follow Michigan DEQ siting requirements. Michigan DEQ

³¹ The Ohio general NPDES permit for HSTS provides coverage for dischargers from select new, replacement, or updated HSTSs serving single-family, two-family or three-family dwellings or residential dwellings or appurtenances as defined by OAC Chapter 3701-29 to waters of the state. The general permit does not cover any discharges that the Ohio EPA Director has determined to be contributing to a violation of a water quality standard.

³² For more information on the accreditation process, and minimum program requirements, please visit <https://accreditation.localhealth.net/>.

does not have an OWTS installer licensing program. In the SJRW, OWTS installers must register with BHSJ. The agency does not perform *point of sale* inspections but will inspect existing OWTS during a *change of use* (e.g., mobile home converted to permanent home)³³ or when repairs or new system installations are being conducted. Neither Michigan DEQ nor BHSJ fund assistance programs to help residents replace their OWTS in the SJRW.

Michigan DEQ tracks the permitting of HSTS and non-residential OWTS. An estimated 18,547 households were in Hillsdale County, with 6,073 households connected to public sewers, 12,064 households used HSTS, and 410 households used other methods of wastewater treatment (West Virginia University nd). No information regarding failure rates specific to Hillsdale County or southern Michigan is available. The state of Michigan summarizes the failure data into annual statewide reports, which can be found on Michigan's Onsite Wastewater website (go to <http://www.michigan.gov/deq>) and search for "Onsite wastewater".

4.3.2.3 Ohio

In Ohio, according to *OAC 3718-01(F)*, any decentralized wastewater treatment systems "that receive sewage from a single family, two-family, or three-family dwelling" is defined as a HSTS. Only HSTS are discussed hereafter because no other decentralized wastewater treatment systems³⁴ are known to operate in the SJRW project area.

The Ohio Department of Health (ODH) regulates HSTS and provides technical assistance to the local health districts for HSTS-issues. Ohio EPA grants general NPDES coverage for off-site discharging HSTS; however, no such permit coverage has been granted in the SJRW. The local health districts permit and inspect HSTS in Ohio. In the SJRW, the Williams County Health District's Environmental Division maintains a wastewater septic system program.

ODH conducted an HSTS study in 2012 to support Ohio EPA's CWA requirements. As reported in the *Household Sewage Treatment System Failures in Ohio* (ODH 2013), approximately 31 percent of HSTS in Ohio are failing; results for pertinent areas are displayed in Table 13.

Table 13. HSTS and failure rates in two counties in the SJRW

Area	No. of HSTS	No. of failing HSTS	Failure rate ^a
Ohio	628,493	193,988	31%
Northwest District ^b	117,819	45,560	39%
Defiance County	2,702	1,432	53%
Williams County	496	484	98%

Sources: ODH 2012

Notes

- a. The estimate failure rate includes systems that are old or are no longer allowed to be installed (e.g., discharger to dry wells).
- b. Ohio EPA's Northwest District consists of the following counties: Allen, Ashland, Auglaize, Crawford, Defiance, Erie, Fulton, Hancock, Hardin, Henry, Huron, Lucas, Marion, Mercer, Ottawa, Paulding, Putnam, Richland, Sandusky, Seneca, Van Wert, Williams, Wood and Wyandot.

The most common types of HSTS in Ohio are *septic tank or pretreatment to leaching* (43 percent) and *septic tank or pretreatment to discharge* (17 percent). Most of the Ohio-portion of the SJRW is in Williams County, and *Septic tank or pretreatment to discharge* (65 percent) and *septic tank or pretreatment to unknown* (33 percent) are the most common types of HSTS in Williams County (Table

³³ Aaron Parker, Michigan DEQ, personal communication (via electronic mail), March 19, 2015.

³⁴ Other types of decentralized wastewater treatment systems that are not HSTS, as defined in Ohio, include systems that treat sanitary waste from one or more businesses.

14). Privies (outhouses) were not reported in this county. ODH's 2012 HSTS study identified 322 discharging HSTS in Williams County (ODH 2012).

Table 14. HSTS types and failure rates in Williams County

HSTS type	No. of HSTS	No. of failing HSTS	Failure rate ^a
Septic tank or pretreatment to leaching	1	0	0%
Septic tank or pretreatment to mound system	8	1	13%
Septic tank or pretreatment to sand filter	0	--	--
Septic tank or pretreatment to discharge	322	319	99%
Septic tank or pretreatment to unknown	165	164	99%
Dry wells	0	--	--
Unknown	0	--	--
Other:	0	--	--

Sources: ODH 2012

Notes

a. The estimate failure rate includes systems that are old or are no longer allowed to be installed (e.g., discharger to dry wells).

b. Dry well systems are no longer allowed and are considered to be failing.

Across Ohio, of the known systems³⁵, 49 percent of *septic tank or pretreatment to discharge* are reported as failing (ODH 2013). Of the known systems in Williams County, 99 percent of *septic tank or pretreatment to discharge* are reported as failing. HSTS can be reported as failing for one or more reasons. The most common reasons for system failures in Ohio are old systems (44 percent), direct discharges exceed water quality standards (43 percent), and soil limitations (33 percent). Dry well systems are no longer allowed to be installed and all such systems are considered to be failing.

4.3.2.4 Indiana

HSTS are regulated by local health departments in Indiana, while IDEM regulates municipal OWTS. In the early 2000s, an estimated 40 to 50 percent of HSTS in DeKalb County were failing, which is similar to the 40 percent estimated failure rate across Indiana (Rice 2005, p. 29; SJRWI 2008, p. 68-69). In the Cedar Creek portion of Allen County, an estimated 75 percent of HSTS were failing (Rice 2005, p. 6). As part of its LTCP efforts, Fort Wayne also agreed to implement supplemental environmental projects to eliminate septic systems from its jurisdiction (Fort Wayne 2007, Appendices 6 and 7).

4.3.3 Fertilizers and Pesticide Application to Manicured Lawns and Crop Fields

Application of chemicals, including pesticides and fertilizers, is a potential source of nitrogen and phosphorus species in both urban and rural environments. During precipitation events, fertilizers and pesticides can wash off manicured lawns and crop fields and travel overland or through drain tiles or storm sewers to surface streams. Nutrients may travel dissolved in solution or bound to sediment.

Unless ammonia is bound to sediment, it will nitrify to nitrate, which contributes to eutrophication and nutrient impairments. Ammonia and total phosphorus derived from fertilizers or pesticides may bind to sediment and travel downstream; such pollutants may persist in the environment long after fertilizer or pesticide application. Finally, the effects of fertilizer-derived loads may be seasonal because fertilizers are applied during the growing season, which varies by crop or landscaped plant.

4.3.3.1 Developed Land

In urban areas, pesticides and fertilizers are applied to manage developed areas such as residential lawns and gardens, athletic fields, parks, recreational facilities, and green spaces surrounding larger industrial or commercial complexes³⁶. After precipitation events, pesticides and fertilizers can contribute pollutants to runoff that enters streams through the storm sewers.

³⁵ The type of HSTS can be reported as 'unknown'; 56 percent of unknown systems were reported as failing. Additionally, 51 percent of *septic tank or pretreatment to unknown* were failing.

³⁶ Scotts Miracle Gro-Company, whose retail sales compose one-half of lawn fertilizer sales in Ohio, eliminated phosphorus from its lawn maintenance products in 2013 (Ohio EPA 2013, p. 10).

SJRWI (2008) identified greenspaces in Fort Wayne along the SJR as potential sources of fertilizers that migrate into the SJR; such green spaces include IPFW campus, Canterbury Green, Shoaff Park, Concordia University, and River Bend Golf Course.

4.3.3.2 Cultivated Crops

Smith et al (2015b) identified 23 factors that interact in a complex process that results in elevated nutrient loads to Lake Erie. A few factors pertinent to cultivated crops are discussed herein. Generally, in the Western Basin of Lake Erie, crop rotations have transitioned from 4-year and 10-year rotations of multiple crops to 2-year corn-soybean and 3-year corn-soybean winter wheat rotations. The less diverse rotations require more fertilizer application, with corn, specifically, requiring more nutrient fertilizer application than other crops (Smith et al. 2015b, p. 27a). Fertilizer placement, timing, and rate are critical factors that affect phosphorus transport to Lake Erie. Surficial broadcast application tends to occur in the non-growing season (which has less crop uptake of nutrients and more wet, runoff conditions) at higher application rates (which were designed for less productive soils and are high enough to ensure sufficient yield and maintain nutrient levels in the soil) results in more risk of phosphorus loss to runoff (Smith et al. 2015b, p. 27a-28a).

Cultivated crop fields are present throughout the project area and on properties adjacent to impaired streams. Fertilizer application is dependent on numerous factors (e.g., soil type, soil moisture content, crop type). In Ohio the most common fertilization practices are broadcast (no till, 31 percent; till seven or more days after application, 15 percent; and till within seven days of application, 18 percent) and incorporation (with strip tillage, 4 percent; planter, 33 percent) (Ohio EPA 2013b). The following four crops are the most prevalent in the project area and are each briefly discussed: corn, soybean, winter wheat, and hay/alfalfa. The following descriptions of fertilizer application in the SJR TMDL project area are generalized:

- **Corn:** Farmers often apply 28-0-0 solution as a starter fertilizer during spring planting. They will then also side-dress nitrogen-fertilizers 30-days after planting. About half of the farmers use anhydrous ammonia while the other half use 28-0-0 solution.

About 30 to 40 percent of farmers spring-apply a phosphorus fertilizer just before planting; the other 60 to 70 percent of farmers fall-apply phosphorus fertilizer.

- **Soybean:** No fertilizers are applied during the soybean portions of the crop rotations.
- **Winter wheat:** Farmers broadcast 28-0-0 solution or dry 46-0-0 in the spring after fall planting. Phosphorus-fertilizers are applied during planting in the fall.
- **Hay/alfalfa:** No nitrogen-fertilizer is applied. Phosphorus-fertilizers are applied during planting in the spring.

Cropland roadside surveys in 2004 and 2005 found that the amount of conventional tillage, conservation tillage, and no tillage varied considerably between counties in the St. Joseph River watershed (Palmer & Loomis 2006). No tillage ranged from 17 to 39 percent for corn and 60 to 83 percent for soybeans, while the summation of other conservation tillage practices ranged from 20 to 50 percent for corn and from 9 to 23 percent for soybeans (Palmer & Loomis 2006a, p. 6).

4.3.4 Septage Land Application and Disposal/Treatment

Application of domestic septage to farm fields is regulated by local health departments and state regulatory agencies. Domestic septage is pumped by companies that pump, haul, and dispose of septage. Pumped septage may be hauled to WWTPs for disposal and treatment or hauled to farms for land application to crop fields.

Disposal and treatment of septage at WWTPs generally are not sources of pollutants to surface waterbodies. Septage that is spilled by the haulers or at the WWTPs may migrate to and contaminate streams. However, septage spills, like other spills to surface waterbodies, are illegal and are addressed through the NPDES program.

Domestic septage that is applied to crop fields may be transported via runoff from precipitation events to surface streams. Crop fields with septage application that are drained by tiles will more rapidly transport runoff containing septage to streams and open ditches. The tile drains yield larger and faster flows that can carry septage farther downstream.

4.3.4.1 Michigan

Michigan DEQ's Office of Drinking Water and Municipal Assistance administers a septage program that regulates septage haulers, septage storage facilities, and septage receiving facilities through the issuance of licenses and permits (Michigan DEQ 2013). Michigan DEQ's Septage Waste Program works with local health departments. Septage haulers are licensed and must complete continuing septage education classes to renew their licenses (Michigan DEQ 2013). Septage application to crop fields requires a crop plan, soil analysis, and calculated application rates that must be approved by Michigan DEQ. The Department has issued guidance manuals, including manuals for land application and storage facility maintenance.

Five septage haulers are licensed in Hillsdale County and an additional five are licensed in Branch County. One licensed septage hauler in each county is authorized to land apply septage. However, the only crop field that Michigan DEQ authorized for septage application in Hillsdale County is not in the SJRW.

All ten licensed septage haulers transport septage for disposal and treatment at WWTPs. These 10 licensed septage haulers use one or more of the following four WWTPs:

- City of Three Rivers Clean Water Plant (2 haulers in Branch County)
- Coldwater WWTP (3 haulers in Hillsdale County and 5 haulers in Branch County)
- Leoni Township WWTP (4 haulers in Hillsdale County)
- Rollin-Woodstock WWTP (2 haulers in Hillsdale County)

None of these four WWTPs are in the SJRW, nor do any WWTPs in the SJRW accept septage. Additionally, no septage storage facilities are in the SJRW. Thus, as no septage is land applied in the SJRW, disposed of at WWTPs in the SJRW, or stored in the SJRW, Michigan septage cannot be a source of pollutants for Ohio or Indiana nutrient, TSS, or bacteria impairments in the SJRW.

4.3.4.2 Ohio

ODH, Ohio EPA, and local health districts regulated septage haulers and land application of septage (ODH 2004). ODH provides assistance to local health districts for registering septage haulers, while the local health districts themselves issues the registrations. Domestic septage in Ohio may be transferred to public or private WWTPs, transferred to sanitary landfills, or applied to crop fields (ODH 2004). Ohio EPA is only involved in septage land application if the application causes pollution to waters of the state.

4.3.4.3 Indiana

IDEM Office of Land Quality regulates septage pumping, hauling, and application to crop fields. While WWTPs do accept septage for treatment and disposal, IDEM does not track which facilities treat and

dispose nor does IDEM track where the septage originated from. In the SJRW, the Fort Wayne Municipal WWTP (IN0032191) and Auburn WWTP (IN0020672) accept septage³⁷.

The companies that pump and haul septage are required to maintain records of where they pump septage from and where it is disposed of or treated at; however, haulers do not submit this information to IDEM. Septage pumpers/haulers that land apply must submit quarterly reports that include daily application rates, types of septage (e.g., domestic, grease), and application method (i.e., surface, injection, incorporation)³⁸. No septage land application sites are in the SJRW (Indiana Geological Survey 2013).

4.3.5 Agricultural Ditches and Drain Tiles

Agricultural ditches and drain tiles are installed to drain excess water from cropland. “Tile drainage is essential to efficient agricultural production in the cool humid regions of the upper Midwestern United States” because spring precipitation exceeds evaporation in corn and soybean fields (Smith et al. 2015a, p. 496). Modern agricultural drainage programs began in Ohio in 1957 following the passage of the Ohio Drainage Laws³⁹ (Loftus et al. 2006). Today, drainage ditches and drain tiles are considered to be parts of larger drainage management systems that seek “to improve the soil environment for vegetation growth by managing water for irrigation and drainage” (Ohio EPA 2013a, p. 42). Since the SJRW has low relief and poor natural drainage, many of the tributaries to the St. Joseph River “are actively maintained as open drainage ways by county authorities” (Ohio EPA 2015a, p. 62).

Recent research indicates that “losses of [phosphorus] through tile are likely a prevalent loss pathway throughout the Midwestern United States, particularly where reduced tillage systems may have encouraged the development of macropores” (Smith et al. 2015a, p. 500). Nutrients may rapidly travel from the crop field surface down to drain tiles through macropores, and thus, nutrients would not be sequestered in the soil.

Cropland throughout the SJRW is served by drainage ditches and drain tiles, and while most farms have some form of tiling, not all farms are fully tiled. In a study of crop fields in the SJRW, Smith et al. (2015b) found that 25 percent to 80 percent of phosphorus loss occurred via subsurface drain tiles.

4.3.6 Livestock

Livestock are potential sources of bacteria, nutrients, and sediment (indirectly) to streams, particularly when direct access is not restricted or where feeding structures are adjacent to or connected to riparian areas. As previously discussed in Section 4.2.3, CAFOs are regulated point sources in states’ NPDES Program. Indiana and Ohio operate non-CAFO regulated livestock operations. Many agricultural and rural properties have small numbers of livestock which do not require CAFO⁴⁰ or state permits.

This section includes discussions of general livestock pollution transport pathway information (Section 4.3.6.1), and livestock information specific to Michigan (Section 4.3.6.2), Ohio (Section 4.3.6.3), and Indiana (Section 4.3.6.4). Manure land application is discussed in each section.

4.3.6.1 Background

Livestock with unrestricted access to surface waters may deposit waste directly into streams. While moving along the banks and into streams, hoof shear may loosen soil that is then transported downstream by the creek. Livestock moving along the stream banks may trample or consume vegetation, which

³⁷ Brenda Stephanoff, IDEM Office of Land Quality, personal communication (via electronic mail), August 17, 2015.

³⁸ Brenda Stephanoff, IDEM Office of Land Quality, personal communication (via electronic mail), August 17, 2015.

³⁹ The Ohio Drainage Laws are a colloquial reference to the Ohio County Ditch Law (enacted in 1850) that is composed of ORC Chapters 6131, 6133, 6135, and 6137 (Brown and Stearns 1991).

⁴⁰ CAFOs are regulated under the CWA by U.S. EPA and the states through the NPDES program. Six CAFOs in the SJRW; see Section 4.2.3 and Appendix C for CAFO information.

contributes to bank instability, and ultimately, downstream sedimentation. Livestock that have restricted access to surface waters may still contribute bacteria and nutrients to streams if sufficient practices are not implemented to limit runoff from livestock areas. Finally, runoff from crop fields with manure application can transport bacteria and nutrients in the manure via overland flow or through drain tiles to nearby streams. Manure application varies by season and crop; thus, the magnitude of loads of bacteria, nutrients, and sediment from crop field runoff are controlled by when the manure is applied.

Grazing patterns and the types of cattle operations influence the bacteria, nutrient, and sediment loads that livestock contribute to surface waters. Since livestock grazing patterns vary by season, the pollutant loads derived from livestock vary by season. Runoff from an actively grazed pasture during the spring will yield higher loads than those generated from an unused pasture in the winter when the livestock are in barns.

SJRWI inventoried livestock across the SJRW through windshield surveys in 2009. The inventory identified “1,218 locations where livestock were present” (Quandt 2015, p. 58). The WMPs summarize the inventory per project area. For example, Quandt (2015, p. 58) reported 31,386 head of livestock in the upper SJRW and identified 15 locations with livestock access to streams and 13 locations with manure runoff directly to streams.

4.3.6.2 Michigan

Michigan does not permit non-CAFO livestock operations. Hillsdale County has many small livestock operations that are temporary and change seasonally (SJRWI 2006). Countywide data for Hillsdale County were downloaded from the National Agricultural Statistics Service (NASS 2014) and are presented in Table C-12 and Table C-15 of Appendix C.

Michigan CAFO permits establish requirements for manure land-application. New Michigan rules require farmers who obtain and land-apply CAFO-generated manure to comply with the CAFO land application regulations (Michigan DEQ 2015a).

The Michigan Right to Farm Act, P.A. 93 of 1981, as amended, authorizes the Michigan Commission of Agriculture and Rural Development to develop and adopt Generally Accepted Agricultural and Management Practices (GAAMPs) for farms and farm operations in Michigan. These GAAMPs are based on science and are reviewed annually and revised as considered necessary. GAAMPs promote environmental stewardship, and when MDARD determines that a farm conforms to GAAMPs, then that farmer may use the Right to Farm Act as an affirmative defense in a nuisance lawsuit. If a farm is alleged to be causing a water quality problem, an environmental complaint may be filed by anyone, and an investigation will be conducted by MDARD and/or the MDEQ Water Resources Division. If the management practices on a farm are causing a violation of NREPA Part 31 (Water Resources Protection), then enforcement action may be taken by the MDEQ to address the complaint and compel the farmer to correct the water pollution problem and abate the violation.

Livestock operations may be required to apply for an NPDES permit in accordance with the circumstances set forth in Rule 2196 (R 323.2196) of Part 21 of NREPA. This authority allows the MDEQ to impose pollution controls and conduct inspections, thereby reducing pollutant contamination (i.e., *E. coli* from agricultural operations that have been determined to be significant contributors of pollutants).

4.3.6.3 Ohio

The Ohio Department of Agriculture regulates CAFFs through the Livestock Environmental Permit Program. The CAFF Advisory Committee (of the Ohio Department of Agriculture) defined the numbers of animals that constitute various sizes of CAFFs. The Department issues *Permits to Operate* that require

CAFF owners to submit plans for manure management, insect and rodent control, mortality management, and emergency response (Ohio Department of Agriculture 2011). CAFFs are prohibited from discharging to surface waters. A single CAFF is in the SJRW: Bridgewater Dairy, LLC in Williams County (Table C-14 and Figure C-8 in Appendix C). The Bridgewater Dairy land-applied manure to its own cropland and sells manure to nearby farmers (Bridgewater Dairy 2015)⁴¹. Ohio EPA (2015, p. 17) identified the Bridgewater Dairy as a potential source of nutrients that may increase in-stream nutrient concentrations in Nettle Creek.

Countywide data for Defiance and Williams counties were downloaded from the National Agricultural Statistics Service (NASS 2014) and are presented in Table C-12 and Table C-15 of Appendix C.

Non-permitted operations in Ohio must comply with BMP rules in ODA Division of Soil and Water Conservation's Agricultural Pollution Abatement Program.

- Manure collection, storage, and treatment facilities may not overflow (*OAC-901:13-1-02*) or seep (*OAC-901:13-1-03*) and discharge to waters of the state.
- Manure-contaminated runoff from feedlots and manure management facilities may not discharge to waters of the state (*OAC-901:13-1-04*)
- Land application of manure must comply with the Field Office Technical Guide or similar guidance (*OAC-901:13-1-11*)
- Special procedures for watersheds in distress (*OAC-901:13-1-19*)

OAC Chapter 901-13-1 prohibits manure application in the Western Lake Erie watershed (1) on snow covered or frozen soil, (2) when the top 2-inches of soil are saturated from precipitation, and (3) when the local weather forecast indicate a 50 percent chance of precipitation exceeding 0.5-inch in 24-hours. The exceptions are if (1) the manure is injected into the ground, (2) the manure is incorporated within 24-hours of application, (3) the manure is applied to a growing crop, or (4) during an emergency with pre-approval.

4.3.6.4 Indiana

In Indiana, the IDEM Office of Land Quality regulates both CAFOs and CFOs. Refer to Section 4.2.3 for a discussion of IDEM-issued NPDES CAFO permits. A CAFO is essentially a large CFO. IDEM regulates and must approve facility design and construction/expansion, facility setbacks, manure handling and storage, and manure land application. Eight CFOs are in the Indiana portion of the SJRW (Table C-15 and Figure C-8 in Appendix C).

Small livestock operations and hobby farms are throughout the SJRW in Indiana and some of the small hobby farms allow livestock direct access to streams (Rice 2005). Countywide data for Allen DeKalb, Noble, and Steuben counties were downloaded from the National Agricultural Statistics Service (NASS 2014) and are presented in Table C-12 and Table C-15 of Appendix C.

4.3.7 Wildlife

Wildlife such as deer, raccoon, waterfowl, riparian small mammals (e.g., beaver, otter) can be sources of bacteria and nutrients. The animal habitat and proximity to surface waters are important factors that determine if animal waste can be transported to surface waters. Waterfowl and riparian mammals deposit waste directly into streams while other riparian species deposit waste in the floodplain, which can be transported to surface waters by runoff from precipitation events. Animal waste deposited in upland areas

⁴¹ Liquid manure is applied at a rate of 8,000 to 13,500 gallons per acre and solid manure is applied at 40 to 50 tons per acre (Bridgewater Dairy 2015).

can also be transported to streams and rivers; however, due to the distance from uplands to surface streams, only larger precipitation events can sustain sufficient amounts of runoff to transport upland animal waste to surface waters.

4.3.8 Erosion

Sedimentation and siltation were identified throughout the SJRW. For sedimentation (i.e., deposition of sediment) to occur, a source of sediment must be present. Various forms of erosion are a common source of sediment. Typically, erosion will increase as stream velocity and peak flow increases. Runoff over impervious surfaces and through agricultural drain tiles will have higher velocities and peak flows, and thus, increase erosion.

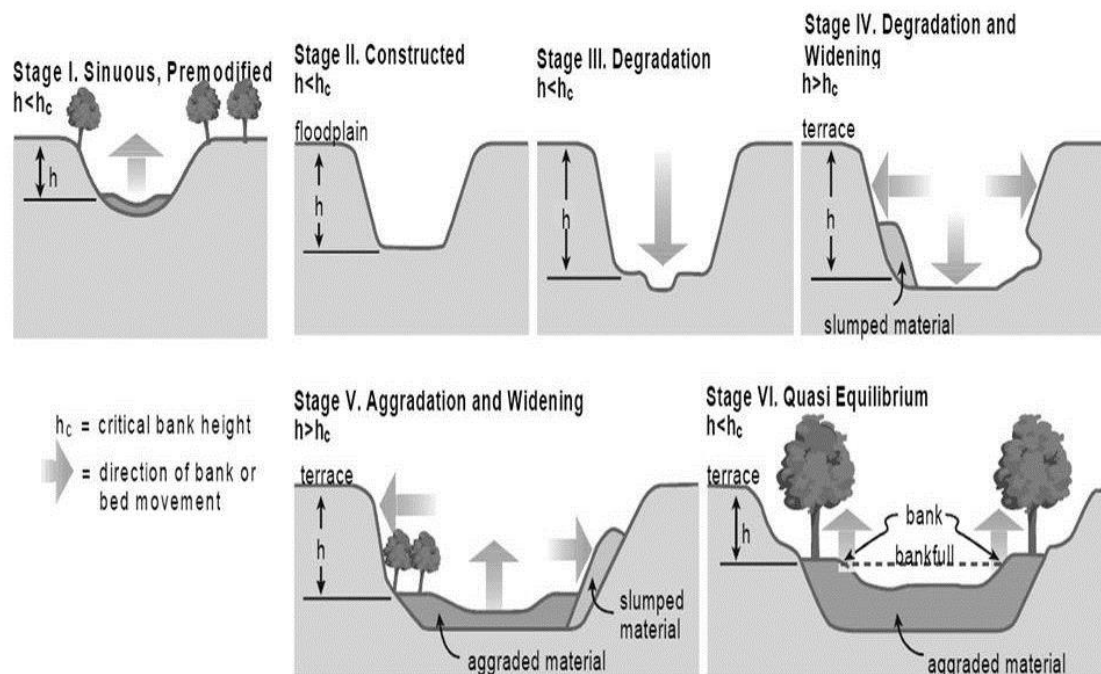
4.3.8.1 Sheet and Rill Erosion

Sheet erosion is the detachment of soil particles by raindrop impact and their removal by water flowing overland as a sheet instead of in channels or rills. Rill erosion refers to the development of small, ephemeral concentrated flow paths, which function as both sediment source and sediment delivery systems for erosion on hillsides. Sheet and rill erosion occur more frequently in areas that lack or have sparse vegetation. Sheet and rill erosion may contribute to a phosphorus impairment if the sediment that is eroded includes phosphorus attached to the sediment particles. Sheet or rill erosion may also transport pathogens from animal waste that was deposited by livestock, pets, or wildlife and from manure or septage that is applied to crop fields. Conservation tillage (e.g., no-till, mulch till, ridge till) “reduces sheet and rill erosion, reduces concentrated flow, and enhances infiltration” (Myers et al. 2000, p. 7).

4.3.8.2 Bank and Channel Erosion

Bank and channel erosion refers to the wearing away of the banks and channel of a stream or river. High rates of bank and channel erosion can often be associated with water flow and sediment dynamics being out of balance. This can result from land use activities that either alter flow regimes, adversely affect the floodplain and streamside riparian areas, or a combination of both. Hydrology is a major driver for both sheet/rill and stream channel erosion.

Stream geomorphology pertains to the shape of stream channels and their associated floodplains. The capacity of a stream system to assimilate pollutants such as sediment, nutrients, and organic matter depends on features related to its geomorphology. This is especially the case for floodplains which, if connected to the channel, can store large quantities of sediment. A conceptual model of channel evolution was used to characterize varying stages of channel modification through time, as illustrated in Figure 15 (Simon and Hupp 1986). Stage I, undisturbed conditions, is followed by the construction phase (Stage II) where vegetation is removed or the channel is modified significantly (through altered hydrology, for example). Degradation (Stage III) follows and is characterized by channel incision. Channel degradation leads to an increase in bank heights and angles, until critical conditions of the bank material are exceeded. Eventually, stream banks fail by mass wasting processes (Stage IV). Sediments eroded from upstream degrading reaches and tributary streams are deposited along low-gradient downstream segments. This process reflects channel aggradation and begins in Stage V. Aggradation continues until stability is achieved through a reduction in bank heights and bank angles. Stage VI (re-stabilization) is characterized by the relative migration of bank stability upslope, point-bar development, and incipient meandering. Stages I and VI represent two true *reference* or attainment conditions.



Source: Simon and Hupp 1986.

Figure 15. Channel evolution model.

Bank erosion is a natural process. Acceleration of this process, however, leads to a disproportionate sediment supply, channel instability, and aquatic habitat loss (Rosgen 2006). Bank erosion processes are driven by two major components: streambank characteristics (e.g., erodibility) and hydraulic forces. Many land use activities affect both these components, which can lead to increased bank erosion. Riparian vegetation and floodplain protection provide internal bank strength. Bank strength can protect banks from fluvial entrainment and subsequent collapse. For instance, when riparian vegetation is changed from woody species to annual grasses, the internal strength is weakened, thus accelerating bank erosion processes. The material from the eroded banks is later deposited via sedimentation in a segment of the stream that is flowing more slowly or where water stops flowing (e.g., a lake).

Confronted by more frequent and severe floods that increase hydraulic forces, stream channels must respond. They typically increase their cross-sectional area to accommodate the higher flows. As described previously, this is done either through widening of the stream banks, down cutting of the stream bed, or frequently both. This phase of channel instability, in turn, triggers a cycle of stream bank erosion and habitat degradation.

Discharge flow rate is a major factor that affects sediment transport in stream systems. Higher discharge volumes lead to increased flow velocities. As channels are incised and flow velocities increase, shear stress and stream power exerted on the channel bed and banks increases. This effect, combined with channel stability, determines the amount of sediment that is mobilized, which in turn influences habitat and aquatic biota. In many areas of the SJRW, storm flows are higher than occurred under predevelopment conditions because of land use changes and increased efficiency brought about by channelization in urban and rural areas. These storm flows have greater power to erode sediment and can transport larger sediment loads downstream. When the sediment finally settles, within a slowly flowing reach or standing waterbody, it may impair aquatic life by filling in fish and benthic macroinvertebrate stream-bottom habitat.

Channelization increases peak flows as it allows flood waves to pass more quickly through the basin, increasing the volume and the erosive force of the water. Because bank erosion is often a symptom of larger, more complex problems, long-term solutions often involve much more than bank stabilization.

4.3.8.3 St. Joseph River Watershed

“Soil-erosion rates from cropland in the Maumee River Basin reported in the tillage transect files range from less than 1.0 to 5.0 ton/acre” (Myers et al. 2000, p. 15). The combined Tiffin River watershed and SJRW contribute little TSS to the Maumee River (9.3 percent) as compared to the combined Auglaize and St. Mary’s rivers watersheds (47 percent), despite the Tiffin and St. Joseph rivers draining 29 percent of the Maumee River basin and the Auglaize and St. Mary’s rivers draining 54 percent of the Maumee River basin (Myers et al. 2000). The poorly drained soils with high runoff potential in the combined Auglaize and St. Mary’s rivers’ watersheds contributed more suspended sediment loads than the moderately to somewhat poorly drained soils with moderate runoff potential in the combined Tiffin and St. Joseph rivers’ watersheds.

4.4 Soil and Water Assessment Tool

Watershed simulation modeling using the U.S. Department of Agriculture’s Agriculture Research Service-supported Soil and Water Assessment Tool (SWAT) was used to support the source assessment and TMDL development⁴². A new SWAT model was developed that incorporates elements of existing SWAT models for the SJRW and Maumee River basin (e.g., Purdue’s SWAT model [Chaubey 2014]). The model results are presented in Section 4.4.2.

4.4.1 Revised SWAT Model

The SWAT model was developed following the requirements set forth in the quality assurance project plan (Tetra Tech 2015). Model development, calibration, validation, and quality assurance/quality control are presented in the model report (Appendix D). The following key factors of the new model distinguish it from the existing models; these updates are described in more detail in the model report:

- The new model was developed in SWAT 2012 revision 635, which was the most recent revision available when modeling activities began in the summer of 2015.
- The model domain was the *St. Joseph River* HU (HUC 041000003).
- Model hydrography was re-delineated to account for the selected model domain, new flowline NHD (revised by USGS), new Ohio EPA water quality and flow sample sites, and TMDL locations for this TMDL study.
- Hydrologic response units were re-developed using the 2011 NLCD (Jin et al. 2013), revised HSGs, and new cropland spatial data from NASS.
- Corn-soybean, corn-soybean-winter wheat, and winter wheat-alfalfa hay were simulated on HSG A and B soils with various tillage practices and application of chemical fertilizers and manure.
- The point sources input boundary conditions include additional point sources (that were not included in existing models either because they were too small or were not yet permitted) and include additional DMR data (i.e., more recent data).

⁴² Tetra Tech did not evaluate other candidate models because rural agriculture composes a considerable portion of the project area, and SWAT is the only available model that incorporates a plant growth model based upon growing degree days and heat units. The plant growth algorithms incorporate nutrient uptake from the soil and thus influences the amount available for transmission to water bodies. Other commonly used watershed simulation models, like Load Simulation Program in C++ and Hydrologic Simulation Program in FORTRAN, do not include plant growth models.

- New HSTS type and failure rate information provided by ODH (2012, 2013) were also incorporated.
- Calibration and validation were performed with expanded datasets that include water chemistry grab samples collected by Ohio EPA in 2013, additional water chemistry grab samples at existing IDEM long-term sample sites (i.e., new data from 2012-2015) and continuous flow data recorded by USGS and Ohio EPA since development of the existing SWAT models.

4.4.2 SWAT Model Results

Two types of SWAT-derived loads are presented in this report

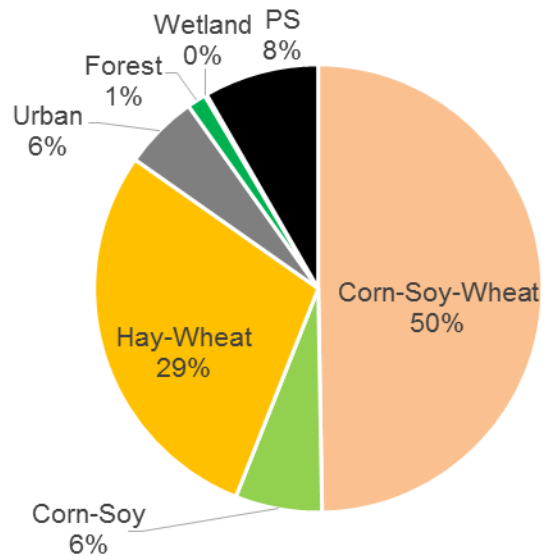
- In-stream loads represent the loads at a particular location, which is cumulative of all upstream load inputs and in-stream processes. These loads are plotted as daily loads on LDCs and used for the calculation of necessary reductions.
- Source loads represent the loads derived from surface and interflow runoff from various hydrologic response units (defined by the land cover, HSG, and slope of a small area) within a single model subbasin. These loads also include model inputs from certain point sources (e.g., WWTPs). Such loads are inputs to the model reaches and do not account for in-stream processes. These loads are plotted as annual average loads (across the 11-year SWAT model simulation period) in pie-charts and used to assess the relative dominance of various types of sources.

The following subsections present a brief discussion of the modeled results by pollutant; SWAT model results are evaluated in greater detail with LDCs and other assessments by subwatershed in Section 5, Section 6, and Appendix F. Basin-scale figures of pollutant loads by 12-digit HU are presented in Appendix E.

4.4.2.1 Total Phosphorus

SWAT-simulated source loads indicate that crops are the dominant source of TP load to streams in the SJRW (Figure 16). Across the SJRW, 56 percent of the TP source load is from Indiana, 23 percent is from Ohio, and 21 percent is from Michigan; these results do not account for in-stream processes. TP source loads from the eight HUC10s vary from 9 to 17 percent of the total load across the SJRW and roughly coincide with land area per HUC10.

Maps of unit area loads of TP are presented in Figure E-1 of Appendix E. As simulated in SWAT, urbanized subwatersheds yielded less unit area TP loads (e.g., Fort Wayne is in subbasins 1 through 5 in Figure E-1, while Auburn is in subbasins 17 and 21 in Figure E-1).



Notes

"PS" = permitted point sources.

Relative loads are rounded to the nearest percentage point.

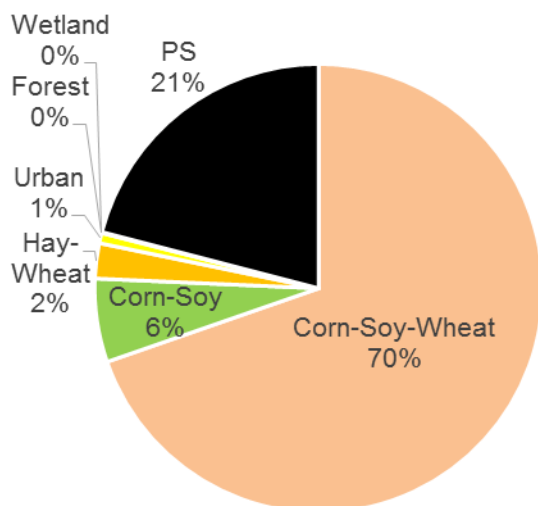
SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) and the loads derived from model inputs for certain point sources. Such loads are inputs to the model reaches and do not account for in-stream processes. Results are summarized as the 11-year average of annual loads by source category.

Figure 16. Summary of SWAT-simulated annual TP loads that drain to streams in the SJRW.

4.4.2.2 Total Suspended Solids

SWAT-simulated source loads indicate that crops are the dominant source of TSS load to streams in the SJRW (Figure 17). Across the SJRW, 63 percent of the TSS source load is from Indiana, 19 percent is from Ohio, and 18 percent is from Michigan; these results do not account for in-stream processes.

Maps of unit area loads of TSS are presented in Figure E-2 of Appendix E. As simulated in SWAT, urbanized subwatersheds yielded less unit area TSS loads (e.g., Fort Wayne is in subbasins 1 through 5 in Figure E-1, while Auburn is in subbasins 17 and 21 in Figure E-2).



Notes

"PS" = permitted point sources.

Relative loads are rounded to the nearest percentage point.

SWAT-simulated source loads represent the loads derived runoff from various hydrologic response units (defined by the land cover, hydrologic soil group, and slope of a small area) and the loads derived from model inputs for certain point sources. Such loads are inputs to the model reaches and do not account for in-stream processes. Results are summarized as the 11-year average of annual loads by source category.

Figure 17. Summary of SWAT-simulated annual TSS loads that drain to streams in the SJRW.

4.5 Load Duration Curves

LDCs were used to assess the sources of pollutants that cause the impairments. Evaluations of LDCs are presented in the subwatershed-by-subwatershed linkage analyses in Section 5 and Section 6 and the LDC charts are presented in Appendix F. This section presents the methods to develop the LDCs.

4.5.1 Flow Duration Curve Development

An LDC is developed from a flow duration curve (FDC) and a target (targets are discussed in Section 4.5.2). A FDC is developed by generating a flow frequency table and plotting the data points to form a curve. The flow data must meet the secondary data requirements described in the QAPP (Tetra Tech 2015; e.g., reasonableness, completeness, and representativeness). The flow data must reflect a range of flows, from extremely high flows to extremely low flows. For the FDCs developed in the SJRW project area, flows were estimated through SWAT modeling.

4.5.2 LDC Targets

TP and TSS LDCs were developed using targets discussed in Section 2.3. In Indiana, targets apply to all streams whereas targets vary by stream size in Ohio. These targets, which were derived from monthly and seasonal analyses, were used as daily LDC targets.

The LDCs used to assess RU impairments were developed for *E. coli* since Indiana and Ohio use *E. coli* as the sole pathogen indicator. As previously described in Section 2.2.2, the seasonal geometric mean criteria were used as daily LDC targets.

4.5.3 Loading Capacity

LDCs are developed using the FDCs and pollutant targets. Essentially, the FDC is multiplied by the pollutant target and then converted to proper units. The LDC is the loading capacity for a given waterbody; for the impaired Indiana or Ohio waterbodies addressed in this TMDL report, the LDC (i.e., loading capacity) is the TMDL. Observed and simulated loads are then plotted with the LDC to determine when the loading capacity of the waterbody is exceeded.

Each of Ohio's and Indiana's water chemistry grab samples was converted to a load by multiplying the concentration by flow and converting to the appropriate units. The flows associated with state agencies' water chemistry samples were SWAT-estimated.

These observed loads and simulated loads are plotted as points with the LDC. Points plotting above the LDC represent deviations from the pollutant target and the allowable load. Those points plotting below the curve represent compliance with pollutant targets and the allowable load. The area beneath the LDC is interpreted as the loading capacity of the stream (the LDC is the maximum loading capacity that is at the concentration of the pollutant target).

5 Aquatic Life Use Linkage Analysis

The objective of this linkage analysis is to provide the link between TP and TSS sources and the observed water quality impairments. For this project area, a weight-of-evidence approach was used to assess the degree that known sources are likely or unlikely contributors to the ALU impairments. This section presents evaluations of water quality data and point source and nonpoint source contributions of TP and TSS and their likely effect on the observed ALU impairments in Indiana. Potential sources that impair designated ALUs (based upon information presented in Section 4) are summarized in Table 16. Summaries of the data are presented in Section F-2 of Appendix F for Indiana.

Eighteen segments across eleven 12-digit HUs are listed for IBC, seven segments across three 12-digit HUs are listed for nutrients, and two segments in different 12-digit HUs are listed for dissolved oxygen (IDEM 2014c). Five TP TMDLs were developed to address IBC listings, two TP TMDLs were developed to address nutrient listings, and one TP TMDL was developed to address IBC and TP listings. All six TSS TMDLs were developed to address IBC listings.

The following sections summarize the available sampling data for each HU with ALU-impaired segments and identify the source(s) that are most likely to cause the impairment. More detailed analyses for each HU are provided in Appendix F. A summary of sources is provided in Table 15.

Table 15. Summary of potential sources of TP and TSS

Potential source	Source assessment	Presence/absence ^a		Discussed in linkage analysis
		No. of sources	No. of HUC12s	
Point Sources				
Facilities covered by individual NPDES permits that discharge treated or untreated sanitary wastewater				
Treated effluent	Section 4.2	13 active facilities	12	Yes ^b
Combined sewer overflows	Section 4.2.2.1	3 communities	3	Yes
Sanitary sewer overflows	Section 4.2.2.2	1 community	1	Yes
Facilities or MS4s covered by individual or general NPDES permits that discharge stormwater				
Construction sites	Section 4.2.5	>250 sites	19	Yes ^c
Industrial facilities		40 facilities	16	Yes ^c
Regulated MS4s		3 MS4s	9	Yes ^c
Animal feeding operations covered by NPDES permits				
Concentrated animal feeding operations	Section 4.2.3	5 CAFOs	4	Yes ^d
Illicit discharges (i.e., not covered by NPDES permits)				
Sanitary sewer cross-connections with storm sewers	Section 4.2.5.2	<i>Assumed present but uncommon</i>		No ^c
Untreated sanitary wastewater	Section 4.2	<i>Assumed absent</i>		No ^c
Unpermitted industrial or construction stormwater discharges	Section 4.2.5	<i>Assumed absent</i>		No ^c
Nonpoint sources				
Crop agriculture				
Fertilizer and pesticide application	Section 4.3.3	<i>Assumed present and common</i>		Yes ^b ,
Land application of biosolids	Section 4.2.2.3	119 fields	15	Yes ^d
Land application of manure	Section 4.3.6	<i>Assumed present</i>		No ^c ,
Land application of septage	Section 4.3.4	<i>None</i>	0	No ^d
Animals				
Confined feeding operation	Section 4.3.6	8 CFOs	7	Yes ^d
Livestock (e.g., hobby farms)	Section 4.3.6	<i>Assumed present</i>		Yes ^c
Wildlife	Section 4.3.7	<i>Assumed present</i>		No ^{c,d}
HSTS				
Properly functioning off-site discharging HSTS	Section 4.3.2	<i>Assumed present</i>		No
Malfunctioning or failing HSTS	Section 4.3.2	<i>Assumed present</i>		Yes ^{c,d}

Notes

CAFO = concentrated animal feeding operation; CFO = concentrated feeding operation; HSTS = household sewage treatment system; MS4 = municipal separate storm sewer system; NPDES = National Pollutant Discharge Elimination System.

a. Presence and absence in the HUC12s in Indiana, which excludes areas of Ohio that drain to one of these WAUs.

b. SWAT modeling was used to evaluate this source

c. No data are available to quantitatively assess the impact of these sources on the impairments.

d. Analysis of qualitative data indicate these sources may contribute to the impairments but their contribution is insignificant.

5.1 West Branch Fish Creek (HUC 041000003 04 01)

West Branch Fish Creek is in Indiana and the subwatershed is bisected by the Indiana East-West Toll Road (I-80) and U.S. route 20. The subwatershed is agricultural with many woodlots. Rural residential properties are adjacent to cultivated crop fields and pastures.

IDEM listed two segments of West Branch Fish Creek (INA0341_01 and INA0341_02) for IBC. IDEM collected samples at two sites on one segment of West Branch Fish Creek. All eight TP and TSS concentrations were below targets (Section F-2.2). As such, TP and TSS TMDLs were not developed for these impaired segments.

5.2 Town of Alvarado-Fish Creek (HUC 041000003 04 05)

This subwatershed begins in Indiana at the confluence of West Branch Fish Creek with Fish Creek. After the confluence, Fish Creek flows southerly toward the Ohio-Indiana border before it then flows southwest away from the border. The landscape is dominated by crop agriculture with some woodlots, especially along Fish Creek. Rural residences are throughout the subwatershed.

5.2.1 Monitoring Data

IDEM collected samples from six sites along Fish Creek and one site on an unnamed tributary to Fish Creek (Section F-2.3). TP and TSS concentrations collected from 1999 through 2014 at long-term site LEJ050-0006 on Fish Creek exceeded applicable targets, especially during high flow conditions. TSS concentrations collected at three additional sites on Fish Creek also exceeded the target. TP and TSS concentrations from the single sample on the unnamed tributary to Fish Creek did not exceed applicable targets. IDEM listed segment INA0345_01 of Fish Creek for IBC and DO.

5.2.2 Sources of Impairment

Potential sources of TP and TSS in this HU are discussed in Section F-2.3. No permitted point sources are in this HU. TP and TSS loads are derived from natural sources (e.g., forest) and anthropogenic nonpoint sources (e.g., OWTS, agriculture). Evaluation of SWAT source loads indicated that crop field runoff was the source of 95 percent of the TP loading and over 99 percent of TSS loading, with hay-winter wheat (63 percent of TP and 34 percent for TSS) and corn-soybean-winter wheat (29 percent of TP and 60 percent of TSS) contributing the most source loading.

5.2.3 Conclusions

One segment in Indiana is listed for IBC and DO. Ambient water chemistry grab samples are not very indicative of impairment due to TP but do indicate some impairment due to TSS. Daily in-stream TP loads and TSS loads simulated in SWAT exceed targets. The anthropogenic sources of TP and TSS loads to the HU are OWTS, unregulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production is the major source of TP and TSS in this HU. The anthropogenic sources were addressed through TP and TSS TMDLs developed at the HU outlet of *Town of Alvarado-Fish Creek* (*04 05). Implementation of TP and TSS TMDLs through the installation of agricultural runoff BMPs should reduce in-stream nutrient and sediment loads.

5.3 Cornell Ditch-Fish Creek (HUC 041000003 04 06)

Fish Creek flows through predominantly agricultural land with few residences and few woodlots in Indiana and Ohio. Only Fish Creek (none of its tributaries) has a forested riparian corridor. The confluence of Fish Creek with the St. Joseph River is in Ohio just upstream of the city of Edgerton.

5.3.1 Monitoring Data

IDEM (seven sites), Ohio EPA (three sites), SJRWI (one site), and USGS (one site) sampled Fish Creek and IDEM (two sites) sampled an unnamed tributary to Fish Creek (Section F-2.4). TP and TSS concentrations collected from 1999 through 2014 at long-term site LEJ050-0007 on Fish Creek exceeded applicable targets. TSS concentrations collected at three additional sites on Fish Creek also exceeded the target. TP and TSS concentrations from one of the two sample sites on the unnamed tributary to Fish Creek exceeded applicable targets. IDEM listed segment INA0346_01 of Fish Creek and segment INA0346_T1003 of the unnamed tributary to Fish Creek for IBC.

5.3.2 Sources of Impairment

Potential sources of TP and TSS in this HU are discussed in Section F-2.4. No permitted point sources are in this HU but point sources are in upstream HUs. An analysis of TP and TSS data indicated that TP is likely bound to sediment and the source of high TP and TSS concentrations is potentially upland and in-channel sediment erosion. Evaluation of SWAT source loads indicated that crop field runoff was the source of 94 percent of the TP loading and 92 percent of TSS loading, with hay-winter wheat contributing the most TP source loading (57 percent) and corn-soybean-winter wheat contributing the most TSS loading (61 percent). SWAT results indicated that upstream point sources contributed 2 percent of the TP loading and 7 percent of the TSS loading.

5.3.3 Conclusions

Two segments in Indiana are listed for IBC. Ambient water chemistry grab samples are not very indicative of impairment due to TP but do indicate some impairment due to TSS. Daily in-stream TP loads and TSS loads simulated in SWAT exceed targets. The anthropogenic sources of TP and TSS loads to the HU are OWTS, unregulated and regulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production is the major source of TP and TSS in this HU. The anthropogenic sources were addressed through TP and TSS TMDLs developed at the HU outlet of *Cornell Ditch-Fish Creek* (*04 06). Implementation of TP and TSS TMDLs through the installation of agricultural runoff BMPs should reduce in-stream nutrient and sediment loads.

5.4 Big Run (HUC 041000003 05 02)

Big Run flows easterly and is mostly in Indiana. The subwatershed includes many named tributaries (e.g., Donnell, John Smith, King, and Mary Metcalf ditches). While most of the subwatershed is rural and agricultural, the city of Butler is mostly in the Big Run subwatershed. U.S. route 6 and railroad lines bisect the subwatershed. As with much of the SJRW, forested woodlots are throughout the subwatershed.

IDEM listed two segments of Big Run (INA0352_04 and INA0352_05) for IBC. TP and TSS data collected from both segments were always below applicable targets (Section F-2.5). As such, TP and TSS TMDLs were not developed for these impaired segments.

5.5 Cedar Lake-Cedar Creek (HUC04100003 06 01)

Cedar Creek begins at the outflow of Cedar Lake in DeKalb County. The main tributary to Cedar Lake is Leins Ditch. About half of the Leins Ditch subwatershed is drained by McCullough Ditch that begins at the outlet of Indian Lake. Besides numerous small lakes and woodlots (including a few large woodlots in the headwaters) the land cover is predominantly agricultural. A small portion of the lower subwatershed includes industrial and commercial development, which is the outskirts of the town of Waterloo (e.g., Techo Bloc quarry and manufacturing facility). The U.S. Route 6 interchange with Interstate 69 is just upstream of the outlet of the subwatershed.

5.5.1 Monitoring Data

IDEM sampled 4 sites in this subwatershed (Section F-2.6). TP and TSS concentrations collected from 2011 through 2014 at long-term site LEJ080-0005 on Cedar Creek exceeded applicable targets. IDEM listed two segments of Cedar Creek (INA0361_03 and INA0361_04) for nutrients.

5.5.2 Sources of Impairment

Potential sources of TP and TSS in this HU are discussed in Section F-2.6. The only permitted point sources are for stormwater covered by general NPDES permits. TP loads are derived from natural sources (e.g., forest) and anthropogenic nonpoint sources (e.g., OWTS, agriculture). Evaluation of SWAT source loads indicated that crop field runoff was the source of 96 percent of the TP loading, with corn-soybean-winter wheat contributing the most TP source loading (54 percent).

5.5.3 Conclusions

Two segments in Indiana are listed for nutrients. Ambient water chemistry grab samples collected at the HU outlet were not evaluated for TP. Daily in-stream TP loads simulated in SWAT infrequently exceed targets. The anthropogenic sources of TP loads to the HU are regulated industrial facility and construction site stormwater, OWTS, unregulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production is the major source of TP in this HU. The anthropogenic sources were addressed through TP a TMDL developed at the HU outlet of *Cedar Lake-Cedar Creek* (*06 01). Implementation of a TP through the installation of agricultural runoff BMPs should reduce in-stream nutrient loads.

5.6 Dibbling Ditch-Cedar Creek (HUC 04100003 06 02)

This subwatershed is composed of a short segment of Cedar Creek from the confluence of Dibbling Ditch to the confluence with Mason Ditch. Most the subwatershed drains to two tributaries of Cedar Creek: Dibbling Ditch and Schwartz Ditch. The Dibbling Ditch subwatershed is almost all rural, agricultural but does include the outskirts of the town of Ashley (to the north of this HU). The Schwartz Ditch subwatershed is also rural and agricultural. Cedar Creek flows along the perimeter of the town of Waterloo.

5.6.1 Monitoring Data

IDEM (3 sites) and SJRWI (4 sites) sampled streams in this subwatershed (Section F-2.7). TP concentrations in SJRWI samples exceeded applicable targets. IDEM listed four segments of Cedar Creek (INA0362_02, INA0362_03, INA0362_04, and INA0363_03) as impaired by nutrients.

5.6.2 Sources of Impairment

Potential sources of TP in this HU are discussed in Section F-2.7. The Waterloo Municipal STP (IN0020711; a sanitary WWTP) and Waterloo Public Water Supply (IN0049433; a WTP) are covered by individual NPDES permits, while general NPDES permits for stormwater discharges cover two industrial facilities and seven construction sites. Except during low-flow conditions, Waterloo Municipal STP effluent TP loads are insignificant; however, large effluent discharges during in-stream low flow conditions would become the dominant source of TP. Evaluation of SWAT source loads indicated that crop field runoff was the source of 89 percent of the TP loading, with corn-soybean-winter wheat contributing the most source loading (56 percent). SWAT results indicated that point sources covered by individual NPDES permits contributed 6 percent of the TP loading.

5.6.3 Conclusions

Four segments in Indiana are listed for nutrients. Ambient water chemistry grab samples collected at the HU outlet were not evaluated for TP. Daily in-stream TP loads simulated in SWAT infrequently exceed

targets. The anthropogenic sources of TP loads to the HU are a WWTP, WTP, regulated industrial facility and construction site stormwater, OWTS, unregulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production is the major source of TP in this HU. The anthropogenic sources were addressed through a TP TMDL developed at the HU outlet of *Dibbling Ditch-Cedar Creek* (*06 02). Implementation of a TP through the installation of agricultural runoff BMPs should reduce in-stream nutrient loads.

5.7 Matson Ditch-Cedar Creek (HUC 04100003 06 03)

The Matson Ditch subwatershed is predominantly rural and agricultural. Residential properties are at a higher density in the lower reaches of the subwatershed in areas closer to the town of Waterloo. The unnamed tributary to Matson Ditch meanders through crop fields and woodlots, with no forested riparian buffers along the segments flowing through crop fields. The unnamed tributary passes through culverts under state route 427 and county roads 16 and 51; it then flows in a straightened channel parallel to country road 51 until its confluence with Matson Ditch.

5.7.1 Monitoring Data

IDEM (1 site) and SJRWI (1 site) sampled streams in this subwatershed (Section F-2.8). IDEM samples indicated nutrient impairment (elevated TP and chlorophyll-*a* concentrations and low DO concentrations). IDEM listed the unnamed tributary to Matson Ditch (INA0363_T1001) as impaired by nutrients.

5.7.2 Sources of Impairment

Potential sources of TP in this HU are discussed in Section F-2.8. No permitted point sources are in this HU. TP loads are derived from natural sources (e.g., forest) and anthropogenic nonpoint sources (e.g., OWTS, agriculture). Evaluation of SWAT source loads indicated that crop field runoff was the source of 95 percent of the TP loading, with corn-soybean-winter wheat contributing the most source loading (57 percent).

5.7.3 Conclusions

One segment is listed for IBC. Few ambient water chemistry grab samples were collected but do indicate an exceedance of TP during low-flows. Daily in-stream TP loads simulated in SWAT infrequently exceed targets in high flow through mid-range flow conditions. The anthropogenic sources of TP loads to the HU are OWTS, unregulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production is the major source of TP in this HU. The anthropogenic sources were addressed through a TP TMDL developed at the confluence of the unnamed tributary to Matson Ditch with Matson Ditch in *Matson Ditch-Cedar Creek* (*06 03). Implementation of a TP TMDL through the installation of agricultural runoff BMPs should reduce in-stream nutrient loads

5.8 Smith Ditch-Cedar Creek (HUC 04100003 06 04)

This subwatershed is composed of Cedar Creek from the confluence of Matson Ditch to the confluence with John Diehl Ditch. Three tributaries in this HU drain to Cedar Creek: Smith Ditch, Metcalf Ditch, and an unnamed tributary. The Smith Ditch subwatershed, upstream of the unnamed tributary to Smith Ditch (INA0364_T1003), is rural and agricultural. Smith Ditch and its unnamed tributary are channelized and straightened without forested riparian buffers. The lower reaches of Smith Ditch (INA0364_T1002) flow through the city of Auburn.

IDEM listed one segment of Smith Ditch (INA0364_T1001) for IBC. IDEM collected samples at one site on the impaired segment of Smith Ditch. All three TP and TSS concentrations were below targets (Section F-2.9). As such, TP and TSS TMDLs were not developed for this impaired segment.

5.9 Peckhart Ditch-John Diehl Ditch (HUC 04100003 07 02)

This HU is composed of the John Diehl Ditch from the confluence of Peckhart Ditch to the confluence with Cedar Creek. Much of the HU is composed of the Peckhart Ditch subwatershed, while most of the John Diehl Ditch subwatershed is contained in the *Headwaters John Diehl Hitch* HU (HUC 041000003 07 01). The largest tributary to Peckhart Ditch is Ober Ditch.

5.9.1 Monitoring Data

IDEM (3 sites) and SJRWI (4 sites) sampled ditches in this subwatershed (Section F-2.10). TP and TSS concentrations in IDEM samples exceeded applicable targets. IDEM listed one segment of Peckhart Ditch (INA0364_T1001) for IBC and DO.

5.9.2 Sources of Impairment

Potential sources of TP and TSS in this HU are discussed in Section F-2.10. The only permitted point sources are for stormwater covered by general NPDES permits. TP loads are derived from natural sources (e.g., forest) and anthropogenic nonpoint sources (e.g., OWTS, agriculture). Evaluation of SWAT source loads indicated that crop field runoff was the source of 95 percent of the TP loading and over 99 percent of TSS loading, with corn-soybean-winter wheat contributing the most source loading (80 percent of TP loading and 91 percent of TSS loading).

5.9.3 Conclusions

One segment is listed for IBC and DO. Few ambient water chemistry grab samples were collected but do indicate an exceedance of TP and TSS during moist conditions. Daily in-stream TP loads simulated in SWAT infrequently exceed targets in high flow and moist conditions, while simulated TSS loads more often exceed in the high flow and moist conditions. The anthropogenic sources of TP and TSS loads to the HU are regulated industrial facility stormwater, OWTS, unregulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production is the major source of TP and TSS in this HU. The anthropogenic sources were addressed through TP and TSS TMDLs developed at the confluence of the Peckhart Ditch with John Diehl Ditch in *Peckhart Ditch-John Diehl Ditch* (*07 02). Implementation of TP and TSS TMDLs through the installation of agricultural runoff BMPs should reduce in-stream nutrient loads.

5.10 Black Creek (HUC 04100003 07 04)

The Black Creek subwatershed is predominantly rural and agricultural. Segments of streams and ditches throughout the subwatershed are straightened and channelized. The western half of the subwatershed drains to Bilger Ditch; most residences are adjacent to row crop fields and there are many undeveloped woodlots. Wahn Ditch is the only major tributary to Bilger Ditch. Below the confluence of Bilger Ditch with Black Creek, Black Creek flows around the town of La Otto. The lower reaches of Black Creek, as it flows due east, are bounded by wider, forested riparian buffers.

5.10.1 Monitoring Data

IDEM (1 site) and SJRWI (3 sites) sampled streams and ditches in this subwatershed (Section F-2.11). TSS concentrations in one IDEM sample exceeded the applicable target. IDEM listed one segment of Black Creek (INA0374_05) for IBC.

5.10.2 Sources of Impairment

Potential sources of TSS in this HU are discussed in Section F-2.11. The LaOtto RSD WWTP (IN0058611; a sanitary WWTP) is covered by an individual NPDES permit, while a general NPDES permit for stormwater discharges cover two construction sites. Effluent TSS loads were typically an order of magnitude less than in-stream TSS loads. Evaluation of SWAT source loads indicated that crop field runoff was the source of 83 percent of the TSS loading, with corn-soybean-winter wheat contributing the most source loading (75 percent). SWAT results indicated that the LaOtto RSD WWTP contributed 17 percent of the TSS loading.

5.10.3 Conclusions

One segment is listed for IBC. Few ambient water chemistry grab samples were collected but do indicate an exceedance of TSS during dry conditions. Daily in-stream TSS loads simulated in SWAT occasionally exceed targets in high flow and moist conditions. The anthropogenic sources of TSS loads to the HU are a sanitary WWTP, regulated construction site stormwater, OWTS, unregulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production is the major source of TSS in this HU. The anthropogenic sources were addressed through a TSS TMDL developed at the HU outlet of *Black Creek* (*07 04). Implementation of a TSS TMDL through the installation of agricultural runoff BMPs should reduce in-stream sediment loads.

5.11 King Lake-Little Cedar Creek (HUC 04100003 07 05)

With the exception of the town of Avilla and city of Garrett in the headwaters of unnamed tributaries to Little Cedar Creek, this HU is predominantly agricultural, with most rural residences adjacent to row crop fields. Several subdivisions have developed near Avilla, Garrett, and in the lower segments of Little Cedar Creek below the confluence of Black Creek (e.g., around the Holiday Lakes). Numerous small ponds and woodlots are scattered across the landscape. King Lake is south of Avilla and is an in-channel lake along an unnamed tributary of Little Cedar Creek.

5.11.1 Monitoring Data

IDEM (2 sites) and SJRWI (3 sites) sampled streams and ditches in this subwatershed (Section F-2.12). TSS concentrations in one IDEM sample exceeded the applicable target. IDEM listed two segments of Little Cedar Creek (INA0375_05 and INA0375_06) and a segment of an unnamed tributary to Little Cedar Creek (INA0375_T1007) for IBC.

5.11.2 Sources of Impairment

Potential sources of TSS in this HU are discussed in Section F-2.12. The Avilla WTP (IN0052035), Avilla WWTP (IN0020664; a sanitary WWTP), and Indian Springs Recreational Campground (IN0032107; a seasonal sanitary WWTP) are covered by individual NPDES permits, while general NPDES permits for stormwater discharges cover two industrial facilities and 10 construction sites. Evaluations of SWAT-simulated in-stream loads indicates that effluent loads are orders of magnitude less than in-stream loads. Evaluation of SWAT source loads indicated that crop field runoff was the source of 84 percent of the TSS loading, with corn-soybean-winter wheat contributing the most source loading (76 percent). SWAT results indicated that point sources covered by individual NPDES permits contributed 16 percent of the TSS loading.

5.11.3 Conclusions

Three segments are listed for IBC. Few ambient water chemistry grab samples were collected but do indicate an exceedance of TSS during dry conditions. Daily in-stream TSS loads simulated in SWAT infrequently exceed targets in moist conditions through dry conditions but frequently exceed during high

flows. The anthropogenic sources of TSS loads to the HU are sanitary WWTPs, a WTP, regulated industrial facility and construction site stormwater, OWTS, unregulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production is the major source of TSS in this HU, although point source loads likely have a significant impact during low flow conditions. The anthropogenic sources were addressed through a TSS TMDL developed at the HU outlet of *King Lake-Little Cedar Creek* (*07 05). Implementation of a TSS TMDL through the installation of agricultural runoff BMPs should reduce in-stream sediment loads.

5.12 Dosch Ditch-Cedar Creek (HUC 04100003 07 07)

This HU begins on Cedar Creek at the confluence of John Diehl Ditch and ends at the confluence of Cedar Creek with the SJR just below the Cedarville Reservoir. The Garret City Ditch and Schmadel Ditch discharge to Cedar Creek in the northern portion of this HU. Little Cedar and Willow creeks discharge to Cedar Creek in the southwest corner of this HU where Cedar Creek switches from flowing southwest to flowing southeast. The lower reaches of Cedar Creek flow through large, forested parcels.

Much of the city of Garrett and the outskirts of the city of Auburn are in the northern portion of this HU. The southeast, lower portion of the HU is composed of subdivisions and the suburban-rural transition along the city of Fort Wayne. Much of the land from Garrett and Auburn to Fort Wayne is row crops with adjacent rural residences.

5.12.1 Monitoring Data

IDEM (15 sites) and SJRWI (4 sites) sampled streams and ditches in this subwatershed (Section F-2.13). TP and TSS concentrations exceeded targets at three sites on Cedar Creek but did not exceed at the site on Dosch Ditch. IDEM listed two segments of Cedar Creek (INA0377_03 and INA0377_04) and one segment of Dosch Ditch (INA0377_T1002) for IBC. IDEM also listed one segment of Dosch Ditch as impaired by nutrients.

5.12.2 Sources of Impairment

Potential sources of TP and TSS in this HU are discussed in Section F-2.13. The Garret City WWTP (IN0029969; a sanitary WWTP), is covered by an individual NPDES permit, while general NPDES permits for stormwater discharges cover three MS4s, four industrial facilities and 17 construction sites. Evaluations of SWAT-simulated in-stream loads indicate that effluent loads are orders of magnitude less than in-stream loads. Permitted point sources are also in upstream HUs. Evaluation of SWAT source loads indicated that crop field runoff was the source of 83 percent of the TP loading and 78 percent of the TSS loading, with corn-soybean-wheat contributing the most source loading (64 percent for TP and 70 percent for TSS). SWAT results indicated that point sources covered by individual NPDES permits contributed 10 percent of TP loading and 21 percent of the TSS loading.

5.12.3 Conclusions

Three segments are listed for IBC and one segment is listed for nutrients. Ambient water chemistry grab samples indicate a few TP exceedances in the high flow and moist conditions and indicate many TSS exceedances in the high flow through mid-range flows. Daily in-stream TP and TSS loads simulated in SWAT infrequently exceed TP targets in high flow through mid-range flows and frequently exceed TSS targets in high flow through dry conditions. The anthropogenic sources of TP and TSS loads to the HU are a sanitary WWTP, regulated MS4, industrial facility, and construction site stormwater, OWTS, unregulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production is the major source of TP and TSS in this HU. The anthropogenic sources were addressed through TP and TSS TMDLs developed at the HU outlet

of *Dosch Ditch-Cedar Creek* (*07 05). Implementation of TP and TSSs TMDL through the installation of agricultural runoff BMPs and urban runoff BMPs should reduce in-stream nutrient and sediment loads.

5.13 *Becketts Run-St. Joseph River (HUC 04100003 08 06)*

This HU begins on the SJR at the confluence of Becketts Run and ends at the confluence of the SJR with the St. Mary's River where the Maumee River is formed. The HU is dominated by the city of Fort Wayne, with subdivisions along Becket's Run and downtown Fort Wayne and dense residential areas in the lower half of the HU.

5.13.1 Monitoring Data

IDEM (8 sites) and SJRWI (2 sites) sampled streams and ditches in this subwatershed (Section F-2.14). TP and TSS concentrations exceeded targets at three sites on the SJR. IDEM listed one segment of the SJR (INA0386_01) for IBC.

5.13.2 Sources of Impairment

Potential sources of TP and TSS in this HU are discussed in Section F-2.14. The DuPont WTP - North End (IN0060127, terminated)⁴³ and Fort Wayne Municipal WWTP (IN0032191; a sanitary WWTP but only CSO and SSO outfalls are in this HU) are covered by individual NPDES permits, while general NPDES permits for stormwater discharges cover two MS4s, two industrial facilities and 63 construction sites. Evaluation of SWAT source loads indicated that crop field runoff was the source of 85 percent of the TP loading and 80 percent of the TSS loading, with corn-soybean-winter wheat contributing the most source loading (50 percent of TP and 66 percent of TSS). SWAT results indicated that point sources covered by individual NPDES permits contributed 8 percent of TP loading and 19 percent of the TSS loading.

5.13.3 Conclusions

One segment is listed for IBC. Ambient water chemistry grab samples indicate a few TP exceedances in the high flow and moist conditions and indicate many TSS exceedances in the high flow and moist conditions and few TSS exceedances in the mid-range flows and dry conditions. Daily in-stream TP and TSS loads simulated in SWAT infrequently exceed TP targets in high flow through mid-range flows and frequently exceed TSS targets in high flow through mid-range flows. The anthropogenic sources of TP and TSS loads to the HU are a CSOs and SSOs at sanitary WWTP, a WTP, regulated MS4, industrial facility, and construction site stormwater, OWTS, unregulated livestock operations, and crop production.

The weight-of-evidence approach indicates that crop production in upstream subwatersheds is the major source of TP and TSS in this HU. The anthropogenic sources were addressed through TP and TSS TMDLs developed at the HU outlet of *Becketts Run-St. Joseph River* (*08 06). Implementation of TP and TSSs TMDL through the installation of agricultural runoff BMPs and urban runoff BMPs should reduce instream nutrient and sediment loads.

⁴³ Dupont WTP (IN0060127) was terminated February 3, 2015. This permit is included in discussion because it was active during the SWAT modeling period and may have contributed to the impairment.

6 Recreational Use Linkage Analysis

The objective of this linkage analysis is to provide the link between bacteria sources and the observed water quality impairments. For this project area, a weight-of-evidence approach was used to assess the degree that known sources are likely or unlikely contributors to the RU impairments. This section presents evaluations of water quality data and point source and nonpoint source contributions of bacteria and their likely effect on the observed RU impairments in Ohio and Indiana. Potential sources of *E. coli* that impair designated RUs (based upon information presented in Section 4) are summarized in Table 16. Summaries of the data are presented in Section F-3 of Appendix F for Indiana. The remainder of this section presents weight-of-evidence analyses by HU.

All 14 of Ohio's WAUs are impaired by *E. coli* (Ohio EPA 2014a) and will be addressed through the development of *E. coli* TMDLs at a later date.

Sixty-one of Indiana's segments are impaired by *E. coli* (IDEM 2014c) and were addressed through the development of *E. coli* TMDLs. Since RU impairments are ubiquitous and subwatershed physical characteristics are fairly homogenous, this linkage analysis is at the 10-digit HU scale.

Table 16. Summary of potential sources of bacteria

Potential source	Source assessment	Presence/absence ^a		Discussed in linkage analysis
		No. of sources	No. of HUC12s	
Point Sources				
Facilities covered by NPDES permits that discharge treated or untreated sanitary wastewater				
Treated effluent ^a	Section 4.2	13 active facilities	12	Yes ^b
Combined sewer overflows	Section 4.2.2.1	3 communities	3	Yes
Sanitary sewer overflows	Section 4.2.2.2	1 community	1	Yes
Facilities or MS4s covered by NPDES permits that discharge stormwater				
Industrial facilities	Section 4.2.5	40 facilities	16	Yes ^b
Regulated MS4s		3 MS4s	9	Yes ^b
Animal feeding operations covered by NPDES permits				
Concentrated animal feeding operations	Section 4.2.3	5 CAFOs	4	Yes
Illicit discharges (i.e., not covered by NPDES permits)				
Sanitary sewer cross-connections with storm sewers	Section 4.2.5.2	<i>Assumed present but uncommon</i>		No ^c
Untreated sanitary wastewater	Section 4.2	<i>Assumed absent</i>		No
Unpermitted industrial stormwater discharges	Section 4.2.5	<i>Assumed absent</i>		No
Nonpoint sources				
Crop agriculture				
Land application of biosolids	Section 4.2.2.3	119 fields	15	No
Land application of manure	Section 4.3.6	<i>Assumed present</i>		Yes ^b
Land application of septage	Section 4.3.4	<i>Absent</i>		No
Animals				
Confined feeding operation	Section 4.3.6	8 CFOs	7	Yes
Livestock (e.g., hobby farms)	Section 4.3.6	<i>Assumed present</i>		Yes
Wildlife	Section 4.3.7	<i>None</i>	0	No ^b
HSTS				
Properly functioning off-site discharging HSTS	Section 4.3.2	<i>Assumed present</i>		No ^c
Malfunctioning or failing HSTS	Section 4.3.2	<i>Assumed present</i>		No ^c ,
Illicit discharges				
Cross-connections with agricultural drain tiles	Section 4.3.2	<i>Assumed present</i>		No ^c
Unpermitted land application of biosolids	Section 4.3.2	<i>Assumed absent</i>		No ^c ,

Notes

CAFO = concentrated animal feeding operation; CFO = concentrated feeding operation; HSTS = household sewage treatment system; MS4 = municipal separate storm sewer system; NPDES = National Pollutant Discharge Elimination System.

a. Facilities that are not permitted to discharge bacteria are excluded (e.g., water treatment plants).

b. No data are available to quantitatively assess the impact of these sources on the impairments.

c. Analysis of qualitative data indicate these sources may contribute to the impairments but their contribution is insignificant.

6.1 Fish Creek (HUC 04100003 04)

Fish Creek flows into and out of Indiana and Ohio and its mouth on the SJR is in Ohio. Like the SJRW, the Fish Creek subwatershed is dominated by rural agriculture and residential property. The lowest reaches of Fish Creek “supported a diverse and well organized community of aquatic organisms” (Ohio EPA 1994a, p. 9). These reaches also support three federally endangered bivalve mollusk species⁴⁴ and three state endangered bivalve mollusk species⁴⁵.

6.1.1 Monitoring Data

Ohio EPA collected 5 samples at three sites (Table F-5) in the Fish Creek subwatershed, while IDEM collected between 2 and 7 samples at 18 sites in the subwatershed (Table F-6). *E. coli* in Ohio ranged from 250 to 1,400 counts/100 mL, with geometric means from 575 to 667 counts/100 mL. All three Ohio assessment sites were in nonattainment. Excluding samples collected from Hamilton Lake, *E. coli* in Indiana ranged from 192 to 17,329 counts/100 mL, with geometric means from 445 to 2,888 counts/100 mL. RU attainment was assessed at 14 locations and IDEM found all 14 sites to be in nonattainment.

6.1.2 Sources of Impairment

Potential sources of *E. coli* in this HU are discussed in Section F-3.2. The Hamilton Lake Conservancy District (IN0050822; a sanitary WWTP) and Hamilton Water Works (IN0060216; a WTP) are covered by individual NPDES permits, while a general NPDES permit for stormwater discharges cover two industrial facilities. Effluent loads were typically orders of magnitude less than in-stream *E. coli* loads.

6.1.3 Conclusions

Two WAUs in Ohio and 9 segments in Indiana are impaired by *E. coli* in *Fish Creek* (HUC 04100003 04). Ambient water chemistry grab samples indicate frequent exceedances. The anthropogenic sources of *E. coli* loads to the HU are a sanitary WWTP, a WTP, regulated industrial facility stormwater, OWTS, unregulated and regulated livestock operations, and crop production.

The weight-of-evidence approach indicates that multiple sources contribute to the *E. coli* impairments in this HU. The anthropogenic sources were addressed through five *E. coli* TMDLs in Indiana:

- West Branch Fish Creek at the outlet of the *West Branch Fish Creek* HU (HUC 04100003 04 01)
- Fish Creek at the outlet of the *Headwaters Fish Creek* HU (*04 02)
- Hiram Sweet Ditch at the outlet of *Hiram Sweet Ditch* HU (*04 04)
- Fish Creek at the outlet of *Town of Alvarado-Fish Creek* HU (*04 05)
- Fish Creek at Indiana-Ohio state line (*04 06)

These sources will also be addressed through two Ohio TMDLs in the SJRW that will be finalized at a later date:

- Fish Creek at the Ohio-Indiana state line (*04 02)
- Fish Creek at the outlet of *Cornell Ditch-Fish Creek* HU (*04 06)

Implementation of *E. coli* TMDLs through the installation of agricultural and urban runoff BMPs should reduce in-stream *E. coli* loads that impair the RU.

⁴⁴ The three federally endangered bivalve mollusk species are: northern riffle shell, club shell mussel, and white catpaw pearly mussel (Ohio EPA 1994a, p. 9).

⁴⁵ The three state endangered bivalve mollusk species are: rayed bean shell, rabbits foot, and purple liliput mussels (Ohio EPA 1994a, p. 9).

6.2 Sol Shank Ditch-St. Joseph River (HUC 04100003 05)

The SJR flows southwest through Williams and Defiance counties, with Big Run joining the SJR before it flows into Indiana. Much of the Big Run subwatershed is in Indiana. Buck Creek and Sol Shank Ditch flow east and join the SJR in Indiana. Big Run flows through Butler, IN, which is the largest developed area in the 10-digit HU, while the SJR flows through the village of Edgerton, OH. Rural agriculture dominates the landscape in both states and this area has less forested riparian buffers and woodlots than the Fish Creek subwatershed to the north.

6.2.1 Monitoring Data

Ohio EPA collected 5 samples from one site on Big Run and 5 to 10 samples from multiple sites on the SJR (Table F-5), while IDEM collected 5 samples from one site on Big Run and 2 samples from one site on the SJR (Table F-6). *E. coli* in Big Run ranged from 78 to 1,210 counts/100 mL with a geometric mean of 290 counts/100 mL; this site was on a segment in non-attainment of its RU. *E. coli* in the SJR was 230 and 260 counts/100 mL; there were insufficient data to assess RU attainment on the SJR.

6.2.2 Sources of Impairment

Potential sources of *E. coli* in this HU are discussed in Section F-3.3. Permitted point sources in Ohio and Indiana are discussed in Section F-3.3.3. The Butler WWTP (IN0022462; a sanitary WWTP with CSOs and SSOs) and Steel Dynamics Inc. (IN0059021; sanitary and industrial waste) are covered by individual NPDES permits in Indiana, while East Side High School (ING250077) and Stafford Gravel, Inc. (ING490043) are covered by general NPDES permits along with six industrial facilities authorized to discharge stormwater. Only sanitary wastewater and industrial stormwater are permitted to contain *E. coli*. Effluent loads were typically orders of magnitude less than in-stream *E. coli* loads.

6.2.3 Conclusions

Four WAUs in Ohio and two of segments in Indiana are impaired by *E. coli* in *Sol Shank Ditch-St. Joseph River* (HUC 04100003 05). Ambient water chemistry grab samples indicate exceedances. The anthropogenic sources of *E. coli* loads to the HU are a sanitary WWTP, an industrial facility with sanitary and industrial waste, regulated industrial facility stormwater, OWTS, unregulated and regulated livestock operations, and crop production.

The weight-of-evidence approach indicates that multiple sources contribute to the *E. coli* impairments in this HU. The anthropogenic sources were addressed through an *E. coli* TMDL in Indiana:

- Big Run at the Indiana-Ohio state line (*05 02)

These sources will also be addressed through four TMDLs in Ohio that will be finalized at a later date:

- SJR at the outlet of the *Bluff Run-St. Joseph River* HU (HUC 04100003 05 01)
- Big Run at the outlet of the *Big Run* HU (*05 02)
- SJR at the outlet of the *Russell Run-St. Joseph River* HU (*05 03)
- SJR at the outlet of the *Willow Run-St. Joseph River* HU (*05 05)

Implementation of *E. coli* TMDLs through the installation of agricultural runoff BMPs should reduce in-stream *E. coli* loads that impair the RU.

6.3 *Mason Ditch-Cedar Creek (HUC 04100003 06)*

Cedar Creek begins at the outflow of Cedar Lake in DeKalb County. Besides numerous small lakes and woodlots (including a few large woodlots in the headwaters) the land cover is predominantly agricultural and rural with the cities of Auburn and Waterloo in the lower portion of the HU. A small portion of the lower subwatershed includes industrial and commercial development.

6.3.1 Monitoring Data

IDEM collected 5 or 6 samples from 5 sites on Cedar Creek and 5 sites on its tributaries (Table F-6). *E. coli* in Cedar Creek ranged from 10 to 25,000 counts/100 mL with geometric means at the 5 sites ranging from 247 to 1,499 counts/100 mL; all of the 5 sites were on segments that did not attain their RU. *E. coli* in the tributaries ranged from 20 to 1,300 counts/100 mL with geometric means at the 5 sites ranging from 155 to 937 counts/100 mL; four sites were on segments that did not attain their RU and one site was on a segment with insufficient data to assess RU attainment.

6.3.2 Sources of Impairment

Potential sources of *E. coli* in this HU are discussed in Section F-3.4. Four industrial facilities discharge non-contact cooling water or industrial process water that is not authorized to contain *E. coli* and are covered by individual NPDES permits. The Auburn WWTP (IN0020672; a sanitary WWTP with CSOs), the Waterloo Municipal STP (IN0020711; a sanitary WWTP), and Waterloo Public Water Supply (IN0049433; a WTP) are also covered by individual NPDES permits. Nine industrial facilities and one MS4 are covered by general NPDES permits for stormwater discharges. Only sanitary wastewater and stormwater are permitted to contain *E. coli*. With the exception of CSOs, effluent loads were typically orders of magnitude less than in-stream *E. coli* loads, only if very large effluent loads occur during low-flow conditions do effluent loads become a significant source of *E. coli*.

6.3.3 Conclusions

Twenty segments in Indiana are impaired by *E. coli* in *Matson Ditch-Cedar Creek* (HUC 04100003 06). Ambient water chemistry grab samples are limited but do indicate exceedances. The anthropogenic sources of *E. coli* loads to the HU are sanitary WWTPs (one with CSOs), regulated MS4 and industrial facility stormwater, OWTS, unregulated and regulated livestock operations, and crop production.

The weight-of-evidence approach indicates that multiple sources contribute to the *E. coli* impairments in this HU. The anthropogenic sources were addressed through four *E. coli* TMDLs:

- Cedar Creek at the outlet of the *Cedar Lake-Cedar Creek* (HUC 04100003 06 01)
- Cedar Creek at the outlet of the *Dibbling Ditch-Cedar Creek* HU (*06 02)
- Unnamed tributary to Mason Ditch at the confluence with Mason Ditch HU (*06 03)
- Cedar Creek at the outlet of the *Smith Ditch-Cedar Creek* HU (*06 04)

Implementation of *E. coli* TMDLs through the installation of agricultural runoff BMPs and urban runoff BMPs should reduce in-stream *E. coli* loads that impair the RU.

6.4 Cedar Creek (HUC 04100003 07)

Lower Cedar Creek begins near Auburn, where Cedar Creek flows southerly toward the Fort Wayne metropolitan area and then flows easterly along the northern boundary of the metropolitan area. Little Cedar Creek is a major tributary to Cedar Creek. Most of the HU south of Auburn and Garrett City is rural and agricultural.

6.4.1 Monitoring Data

IDEM collected 5 to 9 samples from 4 sites on Cedar Creek, 4 to 6 samples from 3 sites on Little Cedar Creek, and 5 or 6 samples from 6 sites on their tributaries (Table F-6).

- **Cedar Creek:** concentrations ranged from 5 to 6,867 counts/100 mL with geometric means at the 4 sites ranging from 236 to 873 counts/100 mL; 3 sites were on segments that did not attain their RU and 1 site was on a segment that had insufficient data to assess RU attainment.
- **Little Cedar Creek:** concentrations ranged from 104 to 2,419 counts/100 mL with geometric means at the 3 sites ranging from 378 to 639 counts/100 mL; all of the 3 sites were on segments that did not attain their RU.
- **Tributaries:** concentrations ranged from 29 to 19,863 counts/100 mL with geometric means at the 6 sites ranging from 64 to 7,196 counts/100 mL; 4 sites were on segments that did not attain their RU and 2 sites were on segments that had insufficient data to assess RU attainment.

6.4.2 Sources of Impairment

Potential sources of *E. coli* in this HU are discussed in Section F-3.5. Several sanitary WWTPs and the Avilla Water Department (IN0052035; a WTP) are covered by individual NPDES permits, while general NPDES permits for stormwater discharges cover nine industrial facilities and an MS4. At the four WWTPs, geometric means of effluent loads were typically several orders of magnitude less than in-stream loads in the high flow through mid-range flow conditions. Effluent loads at elevated concentrations may be contributing significantly to in-stream loads in the low flow zone. Because the effluent DMR does not include raw data, it is not possible to determine if the extremely elevated in-stream concentrations during low flow conditions are due to effluent discharges.

6.4.3 Conclusions

Twenty-three segments in Indiana are impaired by *E. coli* in *Cedar Creek* (HUC 04100003 07). Ambient water chemistry grab samples are limited but do indicate exceedances. The anthropogenic sources of *E. coli* loads to the HU are sanitary WWTPs, regulated MS4 and industrial facility stormwater, OWTS, unregulated and regulated livestock operations, and crop production.

The weight-of-evidence approach indicates that multiple sources contribute to the *E. coli* impairments in this HU. The anthropogenic sources were addressed through five *E. coli* TMDLs:

- Peckhart Ditch at the confluence with John Diehl Ditch (HUC 04100003 07 02)
- Black Creek at the outlet of the *Black Creek* HU (*07 04)
- Little Cedar Creek at the outlet of the *King Lake-Little Cedar Creek* HU (*07 05)
- Willow Creek at the outlet of the *Willow Creek* HU (*07 06)
- Cedar Creek at the outlet of the *Dosch Ditch-Cedar Creek* HU (*07 07)

Implementation of *E. coli* TMDLs through the installation of agricultural runoff BMPs and urban runoff BMPs may reduce in-stream *E. coli* loads that impair the RU.

6.5 St. Joseph River (HUC 04100003 08)

The mainstem SJR in this HU begins downstream of the Ohio-Indiana state border, just below the confluence of Sol Shank Ditch. The HU is predominantly agricultural in the northeast half and transitions to suburban and then urban to the southwest in the greater Fort Wayne metropolitan area. Cedar Creek is the largest tributary to the SJR in this HU. Water is diverted to the Cedarville and Hurshtown reservoirs. At the outlet of this HU, the St. Joseph River joins the Saint Mary's River to form the Maumee River.

6.5.1 Monitoring Data

IDEM collected 5, 6, or 82 samples from 7 sites on the SJR and 2 samples from 1 site on Tiernan Ditch (Table F-6). *E. coli* in the SJR ranged from 5 to 28,000 counts/100 mL with geometric means at the 7 sites ranging from 87 to 1,336 counts/100 mL; 4 sites were on segments that did not attain their RU and 3 sites were on segments that had insufficient data to assess RU attainment. *E. coli* in Tiernan Ditch was 150 and 170 counts/100 mL; this site was on a segment that had insufficient data to assess RU attainment.

6.5.2 Sources of Impairment

Potential sources of *E. coli* in this HU are discussed in Section F-3.6. Several WTPs, Deer Track Estates WWTP (IN0059749; a sanitary WWTP), and Fort Wayne Municipal WWTP (IN0032191 a sanitary WWTP but only CSO and SSO outfalls are in this HU) are covered by individual NPDES permits, while general NPDES permits for stormwater discharges cover 13 industrial facilities and two MS4s. At the Deer Track Estates WWTP, geometric means of effluent loads were typically several orders of magnitude less than in-stream loads.

6.5.3 Conclusions

Three segments in Indiana are impaired by *E. coli* in *St. Joseph River* (HUC 04100003 08). Ambient water chemistry grab samples are limited but do indicate infrequent exceedances. The anthropogenic sources of *E. coli* loads to the HU are sanitary WWTPs (including one with CSOs and SSOs), regulated MS4 and industrial facility stormwater, OWTS, unregulated and regulated livestock operations, and crop production.

The weight-of-evidence approach indicates that multiple sources contribute to the *E. coli* impairments in this HU. The anthropogenic sources were addressed through two *E. coli* TMDLs:

- SJR just upstream of the confluence with Bear Creek (HUC 04100003 08 02)
- SJR at the outlet of the *Swartz Cannahan Ditch-St. Joseph River* HU (*08 03)

Implementation of *E. coli* TMDLs through the installation of agricultural runoff BMPs and urban runoff BMPs may reduce in-stream *E. coli* loads that impair the RU.

7 TMDLS and Allocations

A TMDL is the total amount of a pollutant that a receiving waterbody can assimilate while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. When future growth (FG) is a concern and can be quantified, it is also included. Conceptually, this is defined by the following equation:

$$TMDL = \sum WLA + LA + MOS + AFG$$

The TMDL was calculated at the target, which is typically the most conservative numeric criterion for a given constituent, multiplied by the flow and converted to appropriate units. For example, the total phosphorus TMDL for a hypothetical headwaters stream at the 50th percentile flow (10 cfs) would be calculated as

$$\begin{aligned} TMDL = & (50^{\text{th}} \text{ percentile flow}) \times (\text{target}) \times (\text{conversion factors}) \\ & (10 \text{ cfs}) \times (0.30 \text{ mg/L}) \times (86,400 \text{ s/d}) \times (28.3168 \text{ L/ft}^3) \times (2.205 \times 10^{-6} \text{ lb/mg}) \\ & 16.2 \text{ lb/d} \end{aligned}$$

All loads are reported on a daily time-scale. The loads shown in the TMDL tables are calculated at the flow duration interval that represents the midpoint of the flow zone (e.g., for the high-flow zone [0 to 10th percentile], the TMDL was calculated at the 5th percentile).

7.1 Load Duration Curves

Allowable pollutant loads in the SJRW TMDL project area were determined using LDCs. Discussions of load duration curves are in *An Approach for Using Load Duration Curves in the Development of TMDLs* (U.S. EPA 2007). The LDC approach for this project was presented in Section 4.5. LDCs for the impaired HUs are presented in the linkage analyses presented in Appendix F.

7.2 Allocations

Load duration analyses were conducted for 12-digit HUs that contained one or more impaired segment. For both ALU and RU impairments, LDCs and TMDLs were typically developed at the outlet of a 12-digit HU. In cases where a 12-digit HU was bisected by the Indiana-Ohio state line, LDCs and TMDLs were developed at the state line when Indiana waters flowed into Ohio waters. In similar cases where Ohio waters flowed into Indiana waters, LDCs and TMDLs were developed at the outlet of the 12-digit HU (in Indiana) with a boundary condition set at the state line.

Necessary percent reductions were calculated at TMDL sites using the LDCs IDEM *E. coli*, TP, or TSS monitoring data⁴⁶ and SWAT-estimated flows. The reductions were calculated as the subtraction of the TMDL from the maximum of observed loads per flow zone and then divided by the maximum observed loads per flow zone. This calculation generates the portion of the observed load that must be reduced to achieve the TMDL. The necessary reductions were calculated at the midpoint of the flow duration intervals (e.g., the 5th percentile high flow conditions [0th to 10th percentile]) using the maximum of observed loads within the selected flow duration interval.

⁴⁶ In-stream water quality data were obtained from IDEM.

A summary of the allowable loads and allocations in the project area is presented in this section. TMDL allocation tables are presented in Appendix H.

7.2.1 TMDL Targets and Loading Capacity

TMDL targets for ALU impairments were set to 0.30 mg/L TP (refer back to Section 2.3.1.3) and to 30 mg/L TSS (refer back to Section 2.3.3.3). The targets for each TMDL are presented in Table 18 in Section 0.

TMDL targets for RU impairments were derived from numeric criteria. The targets were based upon the geometric mean criteria for the applicable recreation use (Section 2.2.2). The targets for each TMDL are presented in Table 18 in Section 0.

7.2.2 Load Allocation

The LA is the load contribution from nonpoint sources and natural background levels. It was calculated as the remainder of the load from the loading capacity after the WLAs, MOS, and FGR are allocated.

7.2.3 Upstream State Contribution

Upstream state contributions were calculated for the Indiana SJRW TMDLs where appropriate (i.e., where waters in Ohio drained to an impaired waters in Indiana). Upstream state contributions were developed in response to CWA regulations that discourage upstream or adjacent jurisdictions from negatively impacting the water quality in downstream waters (U.S. EPA 2012b). In the event that downstream waters are determined to be impaired, the upstream contributions must be assigned a portion of the loading capacity (TMDL) for the impaired water. Refer back to Section 2 for a discussion of U.S. EPA (2012) draft guidance on multijurisdictional TMDLs and how U.S. EPA encourages the development of separate loads for upstream or adjacent states in the downstream state's TMDLs.

For Indiana's TMDLs, the upstream state contributions for Ohio are identified as "Ohio upstream contribution" unless Ohio EPA is developing a TMDL for such a location, in which case the upstream contribution in the Indiana TMDL is identified as the name of Ohio EPA's TMDL. For example, Indiana's *E. coli* TMDL for Fish Creek at the outlet of HUC 04100003 04 02 includes an upstream contribution for Ohio that is identified as "Fish Creek (HUC 04100003 04 02; Ohio-Indiana state line)" because Ohio EPA is developing an *E. coli* TMDL at the state line, where Fish Creek flows back to Indiana from Ohio.

Since Ohio EPA is not developing TP or TSS TMDLs for the SJR, Indiana's TP and TSS TMDLs on the SJR include separate upstream state contributions for both Ohio and Michigan, in lieu of allocating to a "Ohio and Michigan combined" upstream states contribution.

7.2.4 Wasteload Allocations

Wasteload allocations were allocated for permitted point sources, including facilities with individual NPDES permits and regulated stormwater (MS4s, construction, and industrial). WLAs are based upon permit limits and design flows, except for WLAs associated with stormwater that were based upon an area ratio of the regulated stormwater area and the TMDL subwatershed. For all TMDLs, the non-stormwater WLAs, MOS, and AFG were allocated first. The remaining load was then allocated to stormwater WLAs and LAs.

7.2.4.1 Individual NPDES Permittees (Non-Stormwater)

WLAs for individual NPDES permittees, except for stormwater individual permittees, were calculated as the design flow multiplied by the effluent limits, as reported in the permit, and converted to proper units. The calculation for the *E. coli* WLA for the Garrett WWTP (IN0029969) is presented below as an example.

$$\begin{aligned} \text{Individual WLA} = & (\text{design flow}) * (\text{monthly average permit limit}) * (\text{unit conversions}) \\ & (1.2 * 10^6 \text{ gpd}) * (125 \text{ counts}/100 \text{ mL}) * (1,000 \text{ mL}/\text{L}) * (3.78541 \text{ L}/\text{gal}) \\ & 5.7 * 10^9 \text{ c/d} \end{aligned}$$

Individual WLAs apply to all flow zones within the LDC-TMDL framework, unless the permits or IDEM identifies unique circumstances for which a WLA would not apply to certain flow zones (e.g., IDEM prohibits dry weather CSO discharges).

For the following three TP TMDLs in Indiana, most of the WLAs for individual NPDES permittees (non-stormwater) were calculated using the July through September average of monthly DMR flow data, in lieu of average design flow, and a TP target of 1.0 mg/L:

- Cedar Creek at the HU outlet (*06 02)
- Cedar Creek at the HU outlet (*07 07)
- SJR at the HU outlet (*08 06)

If the average design flows were used, along with a TP target of 1.0 mg/L, the summation of WLAs would exceed the loading capacity of the streams within the low flow duration zone. During the low flow duration zone, these streams can be dominated by effluent flow. However, the in-stream TMDL target is 0.30 mg/L; thus, during the low flow duration zone, the loading capacity that is dominated by effluent flow is calculated with a 0.30 mg/L TP target while all the effluent load would be allocated using a 1.0 mg/L TP target. Since the summation of WLAs cannot exceed the loading capacity, IDEM decided to allocate individual NPDES (non-stormwater) point sources using the July through September average of monthly DMR flow data that is more representative of summer effluent discharges; these flows are presented in Table 17. For two facilities⁴⁷, the WLAs were calculated using average design flows because the July through September average DMR flows were not less than average design flows.

Table 17. July through September average DMR flows for specified point sources

HUC12	NPDES	Facility	July through September average DMR flow (mgd)
06 02	IN0020711	Waterloo Municipal STP	0.187
07 07	IN0020664	Avila WWTP	0.286
	IN0020672	Auburn WWTP ^a	1.984
	IN0022969	Garrett Municipal WWTP	0.563
	IN0032107	Indian Springs Rec Campground	0.004
	IN0047473	Corunna WWTP	0.013
	IN0058611	La Otto Regional Sewer District	0.020
08 06	IN0022462	Butler WWTP ^a	0.907
	IN0058441	St. Joe - Spencerville RSD	0.065

Notes

DMR = discharge monitoring report; mgd = million gallons per day; NPDES = National Pollutant Discharge Elimination System; STP = sewage treatment plant; WLA = wasteload allocation; WWTP = wastewater treatment plant.

a. Flows for the Auburn WWTP (IN0020672) and Butler WWTP (IN0022462) WLAs for treated effluent. The WLAs for combined sewer overflows were not affected by these low flow duration zone calculations.

⁴⁷ The WLAs for Auburn Gear (IN0000566; does not apply to the separate WLAs for non-contact cooling water or industrial storm water) and Steel Dynamics Inc. (IN0059201; does not apply to the separate WLA for industrial stormwater) were calculated using the average design flows and a TP target of 1.0 mg/L.

7.2.4.2 Individual NPDES Permittees with Industrial Stormwater Discharges

Individual WLAs per industrial facility were developed using a ratio of the areas of the industrial facility and TMDL subwatershed. In cases where an industrial facility covered by an individual NPDES permit has multiple waste streams, separate individual WLAs were developed for stormwater and process water.

The industrial facility's regulated area is the area of the parcel that the address of the permittee is associated with, including adjacent parcels if such parcels are owned by the same entity. The ratio (industrial facility's regulated area divided by TMDL subwatershed area) was rounded up to the next one-tenth of a percent (e.g., 16.36 percent rounded up to 16.4 percent). For very small facilities, when the area-ratio was less than 0.1 percent, then the area-ratio was rounded up to 0.1 percent. A calculation of the ratio for the Contech U.S., LLC (IN0046043) facility in the *Smith Ditch-Cedar Creek* (*06 04) is presented below as an example:

$$\begin{aligned}\text{Ratio} &= (\text{regulated area}) / (\text{TMDL subwatershed area}) \\ \text{Ratio}_{\text{IN0046043}} &= (12.91 \text{ acres}) / (23,334 \text{ acres}) \\ &= 0.00055 \\ &= 0.1 \%\end{aligned}$$

The area-ratio was then applied to the quantity of the TMDL (i.e., the loading capacity) less the summation of non-stormwater WLAs, MOS, and AFG. Because the individual WLAs are calculated using an area-ratio applied to a TMDL that varies by flow condition (i.e., a LDC), the WLA varies by flow condition. A calculation of the WLA for the Contech U.S., LLC (IN0046043) in the *Smith Ditch-Cedar Creek* (*06 04) for *E. coli* in the high flow zone is presented below as an example:

$$\begin{aligned}\text{WLA} &= \text{Ratio} * [\text{TMDL} - (\sum \text{WLA}_{\text{non-stormwater}} + \text{MOS} + \text{AFG})] \\ \text{WLA}_{\text{3ID00070}} &= 0.1\% * [2.05 * 10^{11} - (5.17 * 10^8 + 2.05 * 10^{10} + 1.02 * 10^{10})] \text{ (in counts/day)} \\ &= 0.1\% * [1.74 * 10^{11}] \\ &= 1.74 * 10^8 \text{ counts/day}\end{aligned}$$

7.2.4.3 Individual NPDES Permittees (CSOs)

WLAs for CSOs were developed for the cities of Auburn, Butler, and Fort Wayne based upon their approved LTCPs and/or Consent Decree. The WLAs for each permittee are set to 0 for CSO discharges, this does not mean the immediate prohibition of CSOs, but rather that another mechanism will address the CSOs. The mechanism that implements the CSO WLAs is the LTCP and the NPDES permit, the TMDL does not alter the ongoing activities and efforts of the LTCP. Both TMDLs and LTCPs have the goal of using their unique functions to attain WQS, but the TMDLs should not be seen as superseding LTCPs. Each permittee is working on Long-Term Control Plan implementation with IDEM (and EPA) to address long-term control of CSO discharges to the St. Joseph River. As the LTCPs are implemented, the annual impacts of CSOs upon water quality will be reduced considerably.

7.2.4.4 General NPDES Permittees (Non-Stormwater)

The approach for developing WLAs for individual NPDES permits was also applied to general NPDES permits, unless the general NPDES permits are for stormwater or HSTS.

7.2.4.5 Industrial Stormwater Covered by a General NPDES Permit

Gross WLAs per TMDL subwatershed were developed using a ratio of the summation of the areas of the regulated industrial facilities in each TMDL subwatershed and the area of the TMDL subwatershed. The area-ratio was rounded up to the next one-tenth of a percent (e.g., 0.23 percent rounded up to 0.3 percent).

Then, as described in Section 0, the area-ratio is applied to the quantity of the TMDL less the summation of non-stormwater WLAs, MOS, and AFG.

7.2.4.6 Construction Stormwater Covered by a General NPDES Permit

Gross WLAs per TMDL subwatershed were developed using a ratio of the summation of the areas of the regulated construction sites in each TMDL subwatershed and the area of the TMDL subwatershed. The area-ratio was rounded up to the next one-tenth of a percent (e.g., 0.67 percent rounded up to 0.7 percent). Then, as described in Section 0, the area-ratio is applied to the quantity of the TMDL less the summation of non-stormwater WLAs, MOS, and AFG.

7.2.4.7 Municipal Separate Storm Sewer System Stormwater Covered by a General NPDES Permit

For each regulated MS4 entity, the individual WLA was calculated using a ratio of the surrogate regulated MS4 area to the drainage area of the TMDL subwatershed. The surrogate regulated areas are discussed in Section 4.2.5.5. The surrogate regulated area is then divided by the TMDL subwatershed areas to calculate an area-ratio. As with the industrial stormwater WLAs, the area-ratio is applied to the quantity of the TMDL less the summation of non-stormwater WLAs, MOS, and AFG. Because the individual WLAs are calculated using an area ratio applied to a TMDL that varies by flow condition (i.e., a LDC), the WLA varies by flow condition.

7.2.5 Allocation for Future Growth

AFG were assigned to all TMDLs to account for potential new sources. An AFG of 5 percent was assumed for all Indiana TMDLs based upon best professional judgment. An evaluation of 2000 and 2010 Census data showed that population grew in Allen, DeKalb, Noble and Steuben, counties. Evaluation of individual municipalities showed that the following cities and towns significantly increased in population: Auburn, Avila, Clear Lake, Fort Wayne, Garrett, Hometown, and Leo-Cedarville. The AFG of 5 percent was calculated using county population change (in percent) multiplied by the relative area of each county within the SJRW, and rounded to the nearest percent.

In addition to the explicit AFG, an implicit AFG is in each TMDL with individual NPDES WLAs. As discussed in Section 7.2.4.1, the WLA for each individual, non-stormwater NPDES permittee was developed using the permitted design flow. Most facilities are discharging below design flow; therefore, the facilities have additional capacity (in their WLA) that can be used in the future.

7.2.6 Margin of Safety

The CWA requires that a TMDL include an MOS to account for uncertainty in the relationship between LAs and WLAs and water quality. U.S. EPA guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

Both implicit and explicit MOS were developed. The ALU TMDLs were developed at targets that represent monthly or seasonal averages for reference conditions but were applied as daily TMDL targets. Similarly, the seasonal geometric mean *E. coli* criteria were applied as daily TMDL targets. These are conservative target assumptions. An additional implicit MOS for *E. coli* TMDLs applies because the load duration analysis does not address the die-off of pathogens.

An explicit MOS of 10 percent of the TMDL was allocated for *E. coli* TMDLs and an explicit MOS of 5 percent was allocated for TP TMDLs. This explicit MOS was specified because the use of the load duration curves is expected to provide reasonably accurate information on the loading capacity of the stream, but the estimate of the loading capacity could be subject to potential error associated with the SWAT modeling used to estimate flows in the project area. The 5 percent MOS for the TP TMDLs is to

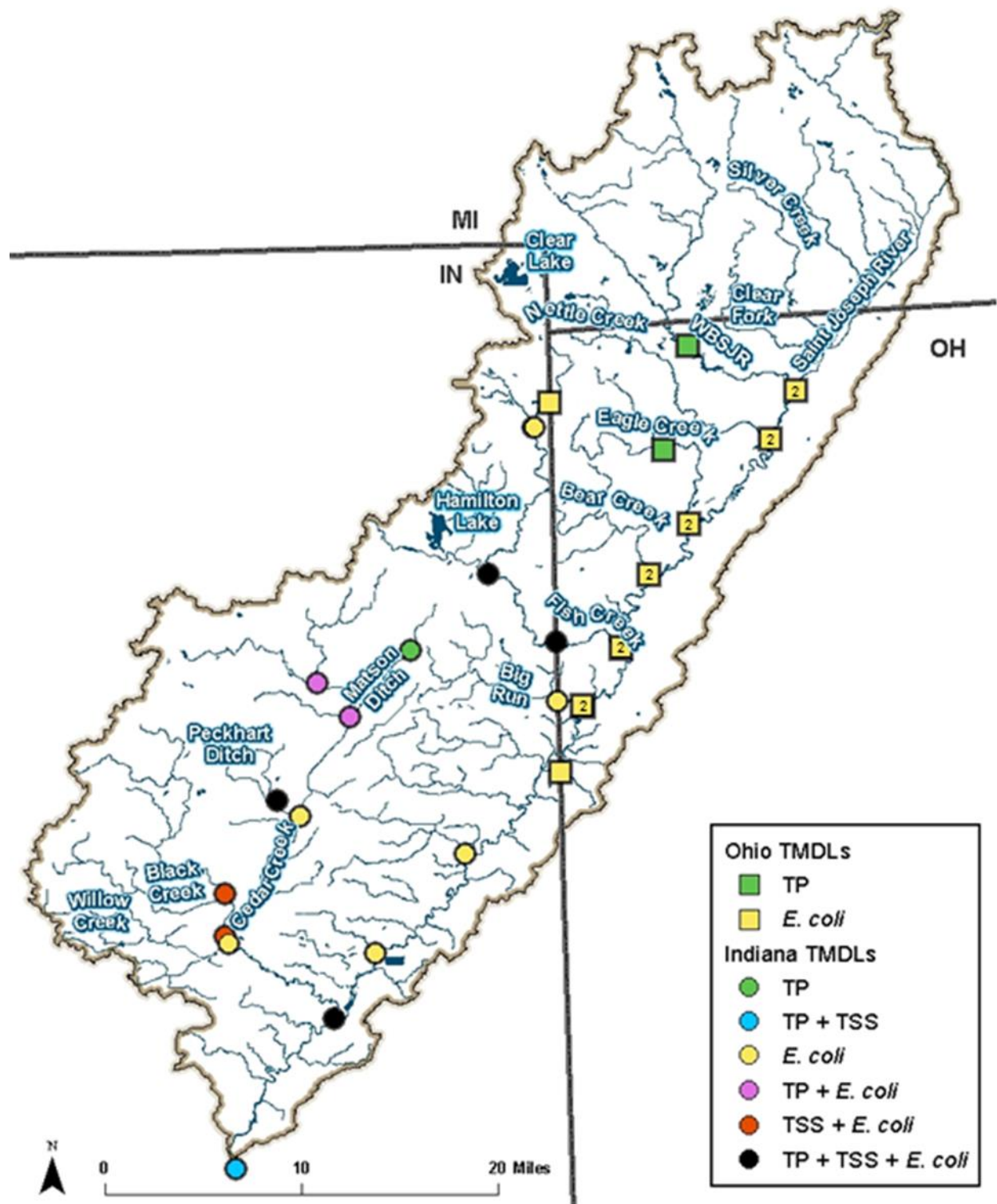
account for the uncertainty associated with the modeling estimates of flow (i.e., the allowable load might be estimated too low if the model underestimates the actual flow in the stream). An additional 5 percent MOS is applied for the *E. coli* TMDLs because bacterial sampling results are highly heterogeneous and analytical determinations of bacterial counts also have relatively low laboratory precision.

7.3 Summary of TMDLs and Reductions

Seventeen HUC12s in Indiana's portion of the SJRW were not in full attainment of their ALUs and RUs. LDC-based TMDLS were developed for each waterbody-pollutant combination (i.e., 32 LDCs). Necessary reductions were calculated for each flow zone of each LDC.

7.3.1 TMDLs

ALU impairments were addressed through eight TP TMDLs and seven TSS TMDLs, while RU impairments were addressed through 17 *E. coli* TMDLs (Figure 18 and Table 18). A TP TMDL and TSS TMDL were developed at the mouth of the SJR; most TMDLs were developed for tributaries.



Notes

TMDL = total maximum daily load; TP = total phosphorus; TSS = total suspended solids.

Ohio *E. coli* TMDL symbols along the SJRW overlap Ohio *E. coli* TMDL symbols at the mouths of tributaries to the SJRW.

Figure 18. TMDLs in the SJRW.

Table 18. LDC and TMDL locations and targets

Stream	Location	Pollutant	Target	Impairments addressed	Site to calculate reductions
Fish Creek (HUC 04100003 04)					
West Branch Fish Creek (HUC 04100003 04 01)					
Fish Creek	HUC12 outlet	E. coli	125	INA0341_01, INA0341_02	LEJ050-0064
Headwaters Fish Creek (HUC 04100003 04 02) ^a					
Fish Creek	HUC12 outlet	E. coli	125	INA0342_01, INA0342_T1003, INA0342_T1004	LEJ050-0023
Hiram Sweet Ditch (HUC 04100003 04 04)					
Hiram Sweet Ditch	HUC12 outlet	E. coli	125	INA0344_03	LEJ050-0054
Town of Alvarado-Fish Creek (HUC 04100003 04 05)					
Fish Creek	HUC12 outlet	TP	0.30	INA0345_01	LEJ050-0006
		TSS	30	INA0345_01	LEJ050-0006
		E. coli	125	INA0345_01	LEJ050-0066
Cornell Ditch-Fish Creek (HUC 04100003 04 06) ^a					
Fish Creek	state border	TP	0.30	INA0346_01, INA0346_T1003	LEJ050-0007
		TSS	30	INA0346_01, INA0346_T1003	LEJ050-0007
		E. coli	125	INA0346_01, INA0346_T1003	LEJ050-0068
Sol Shank Ditch-St. Joseph River (04100003 05) ^a					
Big Run (HUC 04100003 05 02)					
Big Run	state border	E. coli	125	INA0352_03, INA0352_04	LEJ060-0015
Mason Ditch-Cedar Creek (HUC 04100003 06)					
Cedar Lake-Cedar Creek (HUC 04100003 06 01)					
Cedar Creek	HUC12 outlet	E. coli	125	INA0361_03, INA0361_04, INA0361_T1001, INA0361_T1002	LEJ080-0005
Dibbling Ditch-Cedar Creek (HUC 04100003 06 02)					
Cedar Creek	HUC12 outlet	E. coli	125	INA0362_02, INA0362_03, INA0362_04, INA0362_T1004, INA0363_03	LEJ080-0006
Mason Ditch (HUC 04100003 06 03)					
Unnamed tributary to Mason Ditch	confluence with Mason Ditch	TP	0.30	INA0363_T1001	LEJ080-0013
		E. coli	125	INA0363_T1001	LEJ080-0013
Smith Ditch-Cedar Creek (HUC 04100003 06 04)					
Cedar Creek	HUC12 outlet	E. coli	125	INA0364_01, INA0364_02, INA0364_03, INA0364_04, INA0364_05, INA0364_06, INA0364_T1001, INA0364_T1002	LEJ080-0009

Stream	Location	Pollutant	Target	Impairments addressed	Site to calculate reductions
Cedar Creek (HUC 04100003 07)					
Peckhart Ditch-John Diehl Ditch (HUC 04100003 07 02)					
Peckhart Ditch	HUC12 outlet	TP	0.30	INA0372_01	LEJ090-0040
		TSS	30	INA0372_01	LEJ090-0040
		E. coli	125	INA0372_01, INA0372_02, INA0372_T1002, INA0372_T1002A, INA0372_T1003	LEJ090-0034 LEJ090-0040
Black Creek (HUC 04100003 07 04)					
Black Creek	HUC12 outlet	TSS	30	INA0374_05	LEJ090-0041
		E. coli	125	INA0374_03, INA0374_04, INA0374_05, INA0374_T1008, INA0374_T1009, INA0374_T1010	LEJ090-0041
King Lake-Little Cedar Creek (HUC 04100003 07 05)					
Little Cedar Creek	HUC12 outlet	TSS	30	INA0375_05, INA0375_06, INA0375_T1007	LEJ090-0002 LEJ090-0033
		E. coli	125	INA0375_01, INA0375_02, INA0375_03, INA0375_04, INA0375_05, INA0375_06	LEJ090-0010
Willow Creek (HUC 04100003 07 06)					
Willow Creek	HUC12 outlet	E. coli	125	INA0376_02, INA0376_03, INA0376_T1004	LEJ090-0020
Dosch Ditch-Cedar Creek (HUC 04100003 07 07)					
Cedar Creek	HUC12 outlet	TP	0.30	INA0377_03, INA0377_04, INA0377_T1002	LEJ090-0026
		TSS	30	INA0377_03, INA0377_04, INA0377_T1002	LEJ090-0026
		E. coli	125	INA0377_01, INA0377_02, INA0377_03, INA0377_04, INA0377_T1001	LEJ090-0011
St. Joseph River (HUC 04100003 08)					
Metcalf Ditch-St Joseph River (HUC 04100003 08 02)					
SJR	just upstream of Bear Creek	E. coli	125	INA0382_01	LEJ070-0008
Swartz Carnahan Ditch-St Joseph River (HUC 04100003 08 03)					
SJR	HUC12 outlet	E. coli	125	INA0383_01, INA0383_T1003	LEJ070-0026
Becketts Run-St. Joseph River (HUC 04100003 08 06)					
SJR	HUC12 outlet	TP	0.30	INA0386_01	LEJ100-0003
		TSS	30	INA0386_01	LEJ100-0003

Notes

EBSJR = East Branch St. Joseph River; HUC= hydrologic unit code; RM = river mile; SJR = St. Joseph River; WBSJR = West Branch St. Joseph River.

a. TMDLs to address impaired WAUs in Ohio will be published at a later date.

7.3.2 Necessary Pollutant Reductions to Achieve TMDLs

Pollutant reductions are necessary to achieve TMDLs (Table 19). They are calculated as the difference between the observed load with the LDC, and then divided by the observed load. If sufficient observed loads were available, necessary reductions were calculated for each of the five flow zones using the maximum of the observed loads per flow zone and the midpoint of the flow zone (e.g., 5th duration interval for the high flow zone [0th to 10th duration interval]).

Necessary reductions to achieve the *E. coli* TMDLs were calculated using IDEM's grab samples (i.e., observed data) and SWAT-simulated flows. For some TMDLs, only five samples were collected between 2004 and 2014. Thus, few observed loads could be calculated for some flow zones and no reductions could be calculated for other flow zones.

For nine TMDLs, IDEM collected grab samples in 2000 and 2001, which is before the SWAT model simulation period (i.e., 2004-2014). *E. coli* observed loads could not be calculated for these samples, and thus, necessary load reductions could not be calculated. Instead, concentration-based load reductions were calculated. If five samples were collected within a 30 day period during Indiana's recreation season, the geometric mean of those five samples was evaluated with Indiana's geometric mean criterion (see Section 2.2 for a discussion of Indiana's WQS). If less than five samples were collected during such a timeframe, the sample with the largest *E. coli* concentration was compared with Indiana's single sample maximum criterion to calculate a necessary reduction.

For TP and TSS, necessary reductions were also calculated using IDEM grab samples and SWAT-simulated flow. IDEM collected many samples in each flow zone from Fish Creek, Cedar Creek, and the SJR; only a few samples were collected from smaller streams. Due to the lack of data in some flow zones, similar to the *E. coli* evaluation, no observed loads could be calculated for some flow zones and for other flow zones loads would be derived from one or two samples.

Calculated pollutant load reductions for the SJR River ranged from 0 to 99 percent for *E. coli* and from 0 to 66 percent for TP (Table 19), and 14 to 95 percent for TSS (Table 19). Reductions for the tributaries ranged from 14 to 99 percent for *E. coli*, 0 to 84 percent for TP; and 0 to 95 percent for TSS.

Table 19. Necessary pollutant reductions to achieve TMDLs

Stream	RM	Pollutant	High flow (0-10)	Moist conditions (10-40)	Mid-range flows (40-60)	Dry conditions (60-90)	Low flow (90-100)
Headwaters East Branch Black River (HUC 04100003 04)							
West Branch Fish Creek (HUC 04100003 04 01)							
West Branch Fish Creek	outlet	E. coli	--	61%	91%	90%	--
Fish Creek (HUC 04100003 04 02)							
Fish Creek	outlet	E. coli	97% ^a				
Hiram Sweet Ditch (HUC 04100003 04 02)							
Hiram Sweet Ditch	outlet	E. coli	68% ^a				
Fish Creek (HUC 04100003 04 05)							
Fish Creek	outlet	TP	80%	48%	none	none	none
		TSS	83%	92%	50%	none	none
		E. coli	--	--	--	--	89%
Fish Creek (HUC 04100003 04 06)							
Fish Creek	outlet	TP	15%	30%	10%	none	none
		TSS	88%	78%	34%	1%	none
		E. coli	--	--	--	--	93%
Sol Shank Ditch-St. Joseph River (04100003 05)							
Big Run (HUC 04100003 05 02)							
Big Run	state line	E. coli	--	--	--	none	80%
Mason Ditch-Cedar Creek (HUC 04100003 06)							
Cedar Lake-Cedar Creek (HUC 04100003 06 01)							
Cedar Creek	outlet	TP	--	--	--	--	--
		E. coli	99% ^a				
Dibbling Ditch-Cedar Creek (HUC 04100003 06 02)							
Cedar Creek	outlet	TP	--	--	--	--	--
		E. coli	54% ^b				
Mason Ditch (HUC 04100003 06 03)							
unnamed tributary to Mason Ditch	Mouth	TP	--	--	none	none ^c	none
Smith Ditch-Cedar Creek (HUC 04100003 06 04)							
Cedar Creek	Outlet	E. coli	54% ^b				

Stream	RM	Pollutant	High flow (0-10)	Moist conditions (10-40)	Mid-range flows (40-60)	Dry conditions (60-90)	Low flow (90-100)
Cedar Creek (HUC 04100003 07)							
Peckhart Ditch-John Diehl Ditch (HUC 04100003 07 02)							
Peckhart Ditch	outlet	TP	--	11%	none	none	none
		TSS	--	44%	none	18%	none
		E. coli	--	--	93%	99%	>99%
Black Creek (HUC 04100003 07 04)							
Black Creek	outlet	TSS	--	none	--	none	39%
		E. coli	--	--	--	--	84%
King Lake-Little Cedar Creek (HUC 04100003 07 05)							
Little Cedar Creek	outlet	TSS	--	--	--	none	82%
		E. coli	19% ^b				
Willow Creek (HUC 04100003 07 06)							
Willow Creek	outlet	E. coli	84% ^b				
Dosch Ditch-Cedar Creek (HUC 04100003 07 07)							
Cedar Creek	outlet	TP	70%	68%	none	none	none
		TSS	93%	95%	12%	none	none
		E. coli	86% ^b				
St. Joseph River (HUC 04100003 08)							
Metcalf Ditch-St Joseph River (HUC 04100003 08 02)							
SJR	BC ^d	E. coli	80% ^b				
Swartz Carnahan Ditch-St Joseph River (HUC 04100003 08 03)							
SJR	outlet	E. coli	--	87%	none	none	1%
Becketts Run-St. Joseph River (HUC 04100003 08 06)							
SJR	outlet	TP	69%	65%	9%	none	none
		TSS	94%	95%	26%	48%	none

Notes

HUC = hydrologic unit code; RM = river mile; SJR = St. Joseph River; TMDL = total maximum daily load; TP = total phosphorus; TSS = total suspended solids

A double dash ("--") indicates that no observed data are available for the specified flow zone.

A "none" indicates that no reduction is necessary.

a. A concentration-based reduction was calculated using Indiana's single sample maximum criterion because grab samples were collected prior to the model simulation period and less than five samples were collected within a 30-day period in Indiana's recreation season.

b. A concentration-based reduction was calculated using Indiana's geometric mean criterion because grab samples were collected prior to the model simulation period and five samples were collected within a 30-day period in Indiana's recreation season.

c. A single sample of 0.36 mg/L at the 81st flow duration interval is above the LDC; however, the sample is below the LDC at the 75th flow duration interval, which is the midpoint of the dry conditions flow zone.

d. St. Joseph River just upstream of the confluence of Bear Creek.

8 Water Quality Improvement Strategy

Restoration methods to bring an impaired water body into attainment with water quality standards generally involve an increase in the water body's capacity to assimilate pollutants, a reduction of pollutant loads to the water body, or some combination of both. A water quality improvement strategy has been developed to identify the priority activities that can be undertaken to achieve water quality improvements, and eventually attainment of the designated use.

Several sources of anthropogenic pollutants were identified in the project area⁴⁸. The sources of pollutants are discussed in Source Assessment (Section 4) and linkage analyses (Section 5 and Section 6). While no segments of waterbodies in Michigan are listed as impaired for their ALU or RU, waterbodies in Michigan likely contribute pollutant loads to the impaired WAUs in Ohio. As this is an Ohio TMDL report, the focus of the water quality improvement strategy is upon the Ohio WAUs; however, pertinent information regarding Michigan sources and implementation opportunities are included in this chapter.

The goals and indicators of the implementation framework are presented in Section 8.1, while potential best management practices (BMPs) are presented in Section 8.2. Section 8.3 discusses TMDL implementation through Indiana's NPDES programs. Section 8.4 presents programs that can be used to fund implementation activities. Reasonable assurance of TMDL implementation is discussed in Section 8.4.

8.1 Implementation Goals and Indicators

For each pollutant (i.e., *E. coli*, TP, and TSS), IDEM has identified broad goal statements and indicators. This information is to help watershed stakeholders determine how to track implementation progress over time and also provides the information necessary to complete a watershed management plan.

8.1.1 *E. coli* Goal and Indicator

The *E. coli* goal is for each stream in the SJRW to meet the TMDL target of 125 counts per 100 mL. IDEM ambient water quality monitoring will serve as the environmental indicator to determine progress toward achieving the *E. coli* TMDL target.

8.1.2 TP Goal and Indicator

The TP goal is for each stream in the SJRW to meet the TMDL target of 0.30 mg/L. IDEM ambient water quality monitoring will serve as the environmental indicator to determine progress toward achieving the TP TMDL target.

8.1.3 TSS Goal and Indicator

The TSS goal is for each stream in the SJRW to meet the TMDL target of 30 mg/L. IDEM ambient water quality monitoring will serve as the environmental indicator to determine progress toward achieving the TSS TMDL target.

8.2 Implementation Activity Options

Any number or combination of implementation activities might contribute to water quality improvement, whether applied at sites where the actual impairment was identified or at other locations where sources contribute indirectly to the water quality impairment. Table 20 summarizes implementation activities.

⁴⁸ As discussed in Section 2.4, PCBs are not addressed in this TMDL report.

Table 20. Potentially suitable BMPs to achieve TMDLs

Implementation Activities	Pollutant			Point Sources					Nonpoint Sources						
	Bacteria	Nutrients	Sediment	WWTPs and Industrial Facilities	CSOs	Regulated Stormwater Sources	CAFOs	Illicit connections	Cropland	Pastures and Livestock Operations	CFOs	Streambank Erosion	OWTS	Wildlife/Domestic Pets	Urban NPS Runoff
Inspection and maintenance	X	X	X	X	X	X	X						X		
Outreach and education and training	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
System replacement	X	X			X			X					X		
Conservation tillage/residue management	X	X	X						X						
Cover crops	X	X	X						X			X			
Filter strips	X	X	X			X	X		X	X	X	X			X
Grassed waterways	X		X				X		X		X	X			
Riparian forested/herbaceous buffers	X	X	X				X		X	X	X	X		X	X
Manure handling, storage, treatment, and disposal	X	X					X			X	X				
Composting	X	X				X									X
Alternative watering systems	X		X							X		X			
Stream fencing (animal exclusion)	X	X	X							X		X			
Prescribed grazing	X	X	X							X		X			
Conservation easements	X	X	X			X			X	X					X
Two-stage ditches		X	X			X			X			X			X
Rain barrel		X	X			X						X			X
Rain garden		X	X		X	X						X			X
Street rain garden		X	X		X	X						X			X
Block bioretention		X	X		X	X						X			X
Regional bioretention		X	X		X	X						X			X
Porous pavement		X	X		X	X						X			X
Green alley		X	X		X	X						X			X
Green roof		X	X		X	X						X			X
Dam modification or removal		X	X									X			
Levee or dike modification or removal		X	X												
Stormwater planning and management	X	X	X	X	X	X						X	X	X	X

Implementation Activities	Pollutant			Point Sources					Nonpoint Sources						
	Bacteria	Nutrients	Sediment	WWTPs and Industrial Facilities	CSOs	Regulated Stormwater Sources	CAFOs	Illicit connections	Cropland	Pastures and Livestock Operations	CFOs	Streambank Erosion	OWTS	Wildlife/Domestic Pets	Urban NPS Runoff
Comprehensive Nutrient Management Plan	X	X							X		X				
Constructed Wetland	X	X	X	X	X	X		X	X			X		X	X
Critical Area Planting			X							X		X			
Drainage Water Management		X							X			X			
Heavy Use Area Pad	X		X							X					
Nutrient Management Plan		X							X	X		X			
Terrace			X						X						
Land Reconstruction of Mined Land			X									X			
Sediment Basin		X	X			X									X
Pasture and Hay Planting	X	X	X						X	X	X	X		X	
Streambank and Shoreline Protection			X						X	X	X	X		X	X
Conservation Crop Rotation		X	X						X						
Field Border	X	X							X	X	X			X	
Waste Treatment Lagoon	X	X					X			X	X				

Notes

CAFO = concentrated animal feeding operation; CFO = confined feeding operation; CSO = combined sewer overflow; NPS = nonpoint source; OWTS = on-site wastewater treatment system; WWTP = wastewater treatment plant.

Illicit connections represents illicitly connected "Straight Pipe" systems.

8.3 Point Sources

Recommendations for entities covered by NPDES permits can be implemented through IDEM's regulatory authority. Specific recommendations for facilities covered by individual NPDES permits are provided in Section 8.3.1. Sewer systems with CSOs and SSOs are discussed in Section 8.3.2 while entities covered by general NPDES permits are discussed in Section 8.3.3.

8.3.1 Facilities Covered by Individual NPDES Permits in Indiana

Reductions for TP loads will be necessary at several facilities according to calculated TMDLs in locations where TP contribute to ALU impairments. Recommendations for NPDES permits, according to calculated TMDLs, are summarized in Appendix I Table I -1 for TP and Table I-2 for TSS.

Reductions for *E. coli* loads will also be necessary at several facilities according to calculated TMDLs in locations where *E. coli* causes nonattainment of RUs. Recommendations for NPDES permits, according to calculated TMDLs, are summarized by discharger and watershed in Table I -3.

IDEM will work with permit holders to accomplish any needed reductions in loadings. New and renewed individual NPDES permits will account for WLAs allocated during TMDL development. Existing permit conditions for TP, TSS, and *E. coli* for facilities not listed in Table I -1, Table I-2, and Table I -3 should remain unchanged.

8.3.2 Sewer Systems Covered by Individual NPDES Permits with CSOs or SSOs in Indiana

CSOs occurred at three CSSs (i.e., Auburn, Butler, and Fort Wayne) and SSOs were documented at some permitted treatment facilities. The WLAs for each permittee are set to 0 for CSO discharges, this does not mean the immediate prohibition of CSOs, but rather that another mechanism will address the CSOs. WLA are shown in Table I-4, and Table I -5. To comply with the TMDLs, the Auburn, Butler, and Fort Wayne CSSs must comply with their LTCP and their NPDES permits that are both approved by IDEM. Fort Wayne must also comply with its consent decree that is approved by a federal court with input from U.S. EPA and IDEM. The mechanism that implements the CSO WLAs is the LTCP and the NPDES permit, the TMDL does not alter the ongoing activities of the LTCP. Both TMDLs and LTCPs have the goal of using their unique functions to attain WQS, but the TMDLs should not be seen as superseding LTCPs. SSOs received no WLAs because these illicit discharges are prohibited. Through Indiana's regulatory authority, required improvements and compliance schedules for both CSOs and SSOs are written into facilities' NPDES permits. As the LTCPs are implemented and as SSOs are eliminated, the potential impacts of CSOs and SSOs upon water quality will be reduced considerably.

8.3.3 Facilities Covered by General NPDES Permits in Indiana

Industrial facilities that are covered by general NPDES permits received WLAs when such entities contributed to ALU or RU impairments; however, IDEM will not include such WLAs in the renewals of the general permits. Four facilities covered by general permits (non-stormwater; see Table C-3 in Appendix C) received individual WLAs. Facilities that discharge industrial stormwater that are covered by the general NPDES permit are included in HU-scale gross WLAs. Entities covered by the general permit for MS4 stormwater received individual WLAs.

Entities covered by general NPDES permits must comply with permit requirements (e.g., implementing certain BMPs) and IDEM may ensure compliance through the agency's regulatory authority. Additionally, county health departments, local government agencies, and SWCDs work with IDEM and TMDL project area stakeholders to reduce pollutant loads through various environmental and compliance programs.

8.4 Summary of Programs

There are a number of federal, state, and local programs that either require or can assist with the implementation activities recommended for the SJRW in the implementation table. A description of these programs is provided in this section and Table 21 summarizes spending for some of these programs within the SJRW.

Table 21. Fiscal year 2015 funding for programs in the Indiana portion of the SJRW

Program	Type	Agency	Allen County	DeKalb County	Noble County	Steuben County
	Local		\$163,500	\$198,686	\$45,642	\$80,831
CWI	State	SSCB	\$10,000	\$85,885	\$10,000	\$10,885
GBDP		IDNR	--	--	\$5,015	--
LARE		IDNR	\$32,000	\$12,000	\$16,500	\$308,055
WHCP		IDNR	--	--	\$2,461	\$1,170
CRP/CREP	Federal	FSA	\$656,191	\$1,044,500	\$674,498	\$630,812
CSP		NRCS	\$60,987	\$803,612	\$207,320	\$1,309
EQIP		NRCS	\$626,089	\$957,434	\$1,179,519	\$51,688
GRP		NRCS	--	--	\$3,389	--
WRP/WREP		NRCS	\$461,217	\$10,649	--	--
Total			\$2,009,984	\$3,112,766	\$2,144,343	\$1,084,750

Source: Indiana Conservation Partnership (<http://www.in.gov/isda/icpreports/>)

Note: CRP/CREP = Conservation Reserve Program / Conservation Reserve Enhancement Program; CSP = Conservation Stewardship Program; CWI = Clean Water Indiana; EQIP = Environmental Quality Incentives Program; FSA = Farm Service Agency; GBDP = Game Bird Habitat Development Program; GRP = Grassland Reserve Program; IDNR = Indiana Department of Natural Resources; LARE = Lake and River Enhancement Program; NRCS = Natural Resources Conservation Service; SSCB = State Soil Conservation Board; WHCP = Wildlife Habitat Cost-Share Program; WRP/WREP = Wetland Reserve Program / Wetland Reserve Enhancement Program.

8.4.1 Federal Programs

8.4.1.1 Clean Water Act Section 319(h) Grants

Section 319 of the federal CWA contains provisions for the control of nonpoint source pollution. The section 319 program provides for various voluntary projects throughout the state to prevent water pollution and also provides for assessment and management plans related to waterbodies in Indiana impacted by nonpoint source (NPS) pollution. The Watershed Planning and Restoration Section within the Watershed Assessment and Planning Branch of the Office of Water Quality administers the section 319 program for the NPS-related projects.

U.S. EPA offers CWA section 319(h) grant monies to the state on an annual basis. These grants must be used to fund projects that address nonpoint source pollution issues. Some projects which the Office of Water Quality has funded with this money in the past include developing and implementing WMPs, BMP demonstrations, data management, educational programs, modeling, stream restoration, and riparian buffer establishment. Projects are usually two to three years in length. Section 319(h) grants are intended to be used for project start-up, not as a continuous funding source. Units of government, nonprofit groups, and universities in the state that have expertise in nonpoint source pollution problems are invited to submit section 319(h) proposals to the Office of Water Quality.

8.4.1.2 Clean Water Action Section 205(j) Grants

CWA section 205(j) provides for planning activities relating to the improvement of water quality from nonpoint and point sources by making funding available to municipal and county governments, regional planning commissions, and other public organizations. For-profit entities, non-profit organizations, private associations, universities and individuals are not eligible for funding through section 205(j). The

CWA states that the grants are to be used for water quality management and planning, including, but not limited to:

- Identifying most cost effective and locally acceptable facility and non-point source measures to meet and maintain water quality standards;
- Developing an implementation plan to obtain state and local financial and regulatory commitments to implement measures developed under subparagraph A;
- Determining the nature, extent, and cause of water quality problems in various areas of the state.

The section 205(j) program provides for projects that gather and map information on nonpoint and point source water pollution, develop recommendations for increasing the involvement of environmental and civic organizations in watershed planning and implementation activities, and develop watershed management plans.

8.4.1.3 USDA's Conservation Technical Assistance

The purpose of the Conservation Technical Assistance program is to assist land-users, communities, units of state and local government, and other Federal agencies in planning and implementing conservation systems. The purpose of the conservation systems is to reduce erosion, improve soil and water quality, improve and conserve wetlands, enhance fish and wildlife habitat, improve air quality, improve pasture and range condition, reduce upstream flooding, and improve woodlands.

One objective of the program is to assist individual land-users, communities, conservation districts, and other units of State and local government and Federal agencies to meet their goals for resource stewardship and assist individuals in complying with State and local requirements. USDA's Natural Resources Conservation Service (NRCS) assistance to individuals is provided through conservation districts in accordance with the Memorandum of Understanding signed by the Secretary of Agriculture, the Governor of the State, and the conservation district. Assistance is provided to land-users voluntarily applying conservation practices and to those who must comply with local or State laws and regulations.

Another objective is to provide assistance to agricultural producers to comply with the highly erodible land and wetland (Swampbuster) provisions of the 1985 Food Security Act as amended by the Food, Agriculture, Conservation and Trade Act of 1990 (16 U.S.C. 3801 et. seq.), the Federal Agriculture Improvement and Reform Act of 1996, and wetlands requirements of Section 404 of the CWA. NRCS makes HEL and wetland determinations and helps land-users develop and implement conservation plans to comply with the law. The program also provides technical assistance to participants in USDA cost-share and conservation incentive programs.

NRCS collects, analyzes, interprets, displays, and disseminates information about the condition and trends of the Nation's soil and other natural resources so that people can make good decisions about resource use and about public policies for resource conservation. They also develop effective science-based technologies for natural resource assessment, management, and conservation.

There are many programs within the USDA NRCS that assist with water conservation. The 2014 Farm Bill has streamlined many of these programs to further enable farmers, ranchers, and forest landowners to get assistance. These programs include:

- Environmental Quality Incentives Program
- Conservations Stewardship Program
- Agricultural Management Assistance
- Agricultural Water Enhancement Program

- Cooperative Conservation Partnership Program
- Conservation Innovation Grants
- Emergency Watershed Protection Program
- Wildlife Habitat Incentive Program
- Conservation Technical Assistance
- Conservation of Private Grazing Land
- Farm and Ranch Lands protection program
- Agricultural Conservations Easement Program
- Grassland Reserve Program
- Healthy Forest Reserve program
- Wetlands Reserve Program
- Regional Conservation Partnership Program

Currently in the greater Western Lake Erie Basin, there is a Regional Conservation Partnership Program, The Tri-State Western Lake Erie Basin Phosphorus Reduction Initiative that is funded for five years. It is a multi-state RCPP project that brings together more than 40 partnering organizations from Michigan, Ohio and Indiana to reduce the runoff of phosphorous into the Western Lake Erie Basin. A diverse team of partners will use a targeted approach to identify high-priority sub-watersheds for phosphorus reduction and increase farmer access to public and private technical assistance—including innovative demonstrations of practices that NRCS does not yet cover in Michigan, Ohio, and Indiana. Identified actions are coordinated with the Ohio Lake Erie Phosphorus Task Force Report and will move Lake Erie toward goals developed in the Great Lakes Water Quality Agreement Annex 4 Nutrient Strategies. The partners will gage success and monitor results using project-wide water quality monitoring and watershed modeling conducted by national experts from multiple scientific entities and institutions (<http://www.nrcs.usda.gov/wps/portal/nrcs/detail/oh/programs/farmbill/rcpp/?cid=nrcseprd362006>).

8.4.2 State Programs

8.4.2.1 State Point Source Control

The State's Point Source Control, administered by the IDEM Office of Water Quality's Permitting section is charges with fulfillment of the CWA through the NPDES permit program. The purpose of the NPDES permit is to control the point source discharge of pollutants into the waters of the State such that the quality of the water of the State is maintained in accordance with applicable water quality standards. NPDES permit requirements ensure that the minimum amount of control is imposed upon any new or existing point source through the application of technology-based treatment requirements. Control of discharges from WWTPs, industrial facilities, MS4s, and CSOs consistent with WLAs is implemented through the NPDES program. The Storm water and Sediment Control Program works primarily with developers, contractors, realtors, property holders and others to address erosion and sediment concerns on non-agricultural lands, especially those undergoing development.

8.4.2.2 State Nonpoint Source Control Program

The State's Nonpoint Source Program, administered by the IDEM Office of Water Quality's Watershed Planning and Restoration Section, focuses on the assessment and prevention of nonpoint source water pollution. The program also provides for education and outreach to improve the way land is managed. Through the use of federal funding for the installation of BMPs, the development of watershed management plans, and the implementation of watershed restoration pollution prevention activities, the program reaches out to citizens so that land is managed in such a way that less pollution is generated.

Nonpoint source projects funded through the Office of Water Quality are a combination of local, regional, and statewide efforts sponsored by various public and not-for-profit organizations. The emphasis of these projects has been on the local, voluntary implementation of nonpoint source water pollution controls. The

Watershed Planning and Restoration Section administers the section 319 funding for nonpoint source-related projects, as well as section 205(j) grants.

To award 319 grants, Watershed Planning and Restoration Section staff review proposals for minimum 319(h) eligibility criteria and rank each proposal. In their review, members consider such factors as: technical soundness; likelihood of achieving water quality results; strength of local partnerships; and competence/reliability of contracting agency. They then convene to discuss individual project merits and pool all rankings to arrive at final rankings for the projects. All proposals that rank above the funding target are included in the annual grant application to U.S. EPA, with U.S. EPA reserving the right to make final changes to the list. Actual funding depends on approval from U.S. EPA and yearly congressional appropriations.

Section 205(j) projects are administered through grant agreements that define the tasks, schedule, and budget for the project. IDEM project managers work closely with the project sponsors to help ensure that the project runs smoothly and the tasks of the grant agreement are fulfilled. Site visits are conducted at least quarterly to touch base on the project, provide guidance and technical assistance as needed, and to work with the grantee on any issues that arise to ensure a successful project closeout.

8.4.2.3 Indiana State Department of Agriculture Division of Soil Conservation

The Division of Soil Conservation's mission is to ensure the protection, wise use, and enhancement of Indiana's soil and water resources by increasing agricultural economic benefits by assisting Indiana's farmers in the application of advanced agronomic technologies while improving upon Indiana's soil health and water quality.

The Division administers the Clean Water Indiana soil conservation and water quality protection program under guidelines established by the State Soil Conservation Board, primarily through the local SWCDs in direct service to land users. The Division staff includes field-based resource specialists who work closely with land users, assisting in the selection, design, and installation of practices to reduce soil erosion on agricultural land. District Support Specialists work cooperatively with soil and water conservation districts and other conservation partners in the design of programs that reach land users, the general public, governmental officials, and primary and secondary educational institutions on the husbandry and management of soil and water resources. The Storm water and Sediment Control Program works primarily with developers, contractors, realtors, property holders and others to address erosion and sediment concerns on non-agricultural lands, especially those undergoing development.

8.4.2.4 Indiana Conservation Partnership

The Partnership is comprised of eight Indiana agencies and organizations who share a common goal of promoting conservation. To that end, the mission of the Indiana Conservation Partnership is to provide technical, financial and educational assistance needed to implement economically and environmentally compatible land and water stewardship decisions, practices and technologies. Working together, the partnership provides technical, educational, and financial assistance to citizens to solve erosion and sediment-related problems occurring on the land or impacting public waters.

8.4.2.5 Indiana Department of Natural Resources, Division of Fish and Wildlife

The Lake and River Enhancement program utilizes a watershed approach to reduce nonpoint source sediment and nutrient pollution of Indiana's and adjacent states' surface waters to a level that meets or surpasses state water quality standards. To accomplish this goal, the program provides technical and financial assistance to local entities for qualifying projects that improve and maintain water quality in public access lakes, rivers, and streams.

8.4.2.6 State Revolving Fund Loan Program

The State Revolving Fund (SRF) is a fixed rate, 20-year loan administered by the Indiana Finance Authority. The SRF provides low-interest loans to Indiana communities for projects that improve wastewater and drinking water infrastructure. These projects include septic education and mainline hookups. The Program's mission is to provide eligible entities with the lowest interest rates possible on the financing of such projects while protecting public health and the environment. SRF also funds non-point source projects that are tied to a wastewater loan. Any project where there is an existing pollution abatement need is eligible for SRF funding.

8.4.2.7 Hoosier Riverwatch

Hoosier Riverwatch, administered by the IDEM Office of Water Quality Watershed Assessment and Planning Branch, is a water quality monitoring initiative which aims to increase public awareness of water quality issues and concerns through hands-on training of volunteers in-stream monitoring and cleanup activities. Hoosier Riverwatch collaborates with agencies and volunteers to educate local communities about the relationship between land use and water quality and to provide water quality information to citizens and governmental agencies working to protect Indiana's rivers and streams.

8.4.3 Local Programs

Programs taking place at the local level are key to successful TMDL implementation. Local Partners such as the SJRWI and participating county SWCDs are instrumental to bringing grant funding into the SJRW to support local protection and restoration projects. This section provides a brief summary of the local programs taking place in the SJRW that will help to reduce *E. coli*, nutrient, and sediment loads, as well as provides ancillary benefits to the watershed.

8.4.4 Local Watershed Group

The SJRWI and local SWCDs have received grant funding to develop and implement WMPs throughout the SJRW. They continue to follow implementation actions as outlined in the action registers of each WMP. A list of completed watershed management plans for the SJRW is included below:

- Cedar Creek WMP, 01-383, (<http://www.in.gov/idem/nps/3261.htm>)
- St. Joseph River (Lower)-Bear Creek WMP, 5-73, (<http://www.in.gov/idem/nps/3200.htm>)
- St. Joseph River (Maumee) WMP, 02-502, (<http://www.in.gov/idem/nps/3201.htm>)⁴⁹
- St. Joseph River (Middle) WMP, 10-65, (<http://www.in.gov/idem/nps/3901.htm>)⁵⁰
- St. Joseph River (Upper) WMP, 2-16, (<http://www.in.gov/idem/nps/3961.htm>)⁵¹

8.5 Reasonable Assurance

The recommendations made in this TMDL report will be carried out if the appropriate entities work to implement them. In particular, activities that do not fall under regulatory authority require that state and local agencies, governments, and private groups mount a committed effort to carry out or facilitate such actions. For successful implementation, adequate resources must also be available.

⁴⁹ St. Joseph River (Maumee) WMP, 02-502, is for the entire 8-digit HUC that includes portions of Ohio and Michigan.

⁵⁰ St. Joseph River (Middle) WMP, 10-65, includes portions of Ohio.

⁵¹ St. Joseph River (Upper) WMP, 2-16, includes portions of Ohio and Michigan.

When a TMDL is developed for waters impaired by point sources only, the issuance of a NPDES permit(s) provides the reasonable assurance that the WLAs contained in the TMDL will be achieved. This is because title 40 of the *Code of Federal Regulations* section 122.44(d)(1)(vii)(B) requires that effluent limits in permits be consistent with the assumptions and requirements of any available WLA in an approved TMDL.

When a TMDL is developed for waters impaired by both point and nonpoint sources and the WLA is based on an assumption that nonpoint source load reductions will occur, U.S. EPA (1991) TMDL guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions. To that end, IDEM coordinates with organizations and programs that have an important role or can provide assistance for meeting the goals and recommendations of this TMDL. Efforts specific to this watershed are described below.

8.5.1 Lake Erie Western Basin

Charged with coordinating binational actions to manage phosphorous loadings and concentrations in the Great Lakes, Indiana has been an active member of the Nutrients Annex 4 binational subcommittee of the Great Lakes Water Quality Agreement since its establishment in 2013. The Agreement's Lake Ecosystem Objectives include the following:

- Minimize the extent of hypoxic zones in the Great Lakes due to excessive phosphorous loading with emphasis on Lake Erie.
- Maintain levels of algal biomass below nuisance level conditions.
- Maintain algal species consistent with healthy aquatic ecosystems in nearshore waters.
- Maintain cyanobacteria biomass at levels that do not produce concentrations of toxins that pose a threat to human or ecosystem health.
- Maintain an oligotrophic state, relative algal biomass, and algal species consistent with healthy aquatic ecosystems in the open waters of Lakes Superior, Michigan, Huron and Ontario.
- Maintain mesotrophic conditions in the open waters of the western and central basins of Lake Erie, and oligotrophic conditions in the eastern basin of Lake Erie.

Commitments under the Nutrients Annex include the following:

- By February 2016, establish binational Phosphorous objectives, loading targets and allocations for the nearshore and offshore waters to achieve the Lake Ecosystem Objectives for each lake, starting with Lake Erie.
- Assess and where necessary, develop/implement regulatory and non-regulatory programs/measures to reduce phosphorous loadings from agricultural, rural non-farm, urban and industrial point and nonpoint sources.
- By 2018, develop a binational phosphorous reduction strategy and *Domestic Action Plans* designed to meet nearshore and open water phosphorous objectives and loading targets for Lake Erie.

On February 22, 2016, the United States and Canada adopted new phosphorus reduction targets for Lake Erie (Table 22).

Table 22. Binational phosphorus load reduction targets

Lake Ecosystem Objectives Great Lakes Water Quality Agreement Annex 4, Section B	Western Basin of Lake Erie	Central Basin of Lake Erie
Minimize the extent of hypoxic zones in the Waters of the Great Lakes associated with excessive phosphorus loading, with particular emphasis on Lake Erie	40 percent reduction in total phosphorus entering the Western Basin and Central Basin of Lake Erie – from the United States and from Canada – to achieve 600 million tons Central Basin load	
Maintain algal species consistent with healthy aquatic ecosystems in the nearshore Waters of the Great Lakes	40 percent reduction spring total and soluble reactive phosphorus loads from the following watersheds where localized algae is a problem:	
	Thames River – Canada Maumee River – U.S. River Raisin – U.S. Portage River – U.S. Toussaint Creek – U.S. Leamington Tributaries - Canada	Sandusky River – U.S. Huron River, OH – U.S.
Maintain cyanobacteria biomass at levels that do not produce concentrations of toxins that pose a threat to human or ecosystem health in the Waters of the Great Lakes	40 percent reduction in spring total (860 million tons) and soluble reactive phosphorus (186 million tons) loads from the Maumee River (U.S.)	<i>not applicable</i>

Indiana’s Domestic Action Plan will be led by IDEM and developed by a steering committee comprised of representatives from different stakeholder sectors. The Plan will follow an outline that includes: 1) Purpose, 2) Background, 3) Goals, 4) Objectives, 5) Tactics, and 6) Measuring and Reporting Progress.

Indiana’s portion of the Western Lake Erie Basin is comprised of the St. Joseph, Maumee, Auglaize, and St. Mary’s watersheds. The SJR and the St. Mary’s River enter Indiana from Ohio and, at their confluence, form the Maumee River, which flows eastward into Ohio with its mouth at Lake Erie. The 40 percent reduction in spring-time TP and soluble reactive phosphorus noted in Table 22 for the Maumee River translates to a flow weighted mean concentration of 0.23 mg/L TP and 0.05 mg/L soluble reactive phosphorus. Progress toward these target values will be measured on the Maumee River as close to the Indiana-Ohio border as feasible. A draft of Indiana’s Domestic Action Plan will be available by December 31, 2016.

8.5.2 Local Zoning and Regional Planning

Local zoning is typically controlled at the county or municipality level. Local zoning can be a useful tool for implementing some recommendations of the TMDL, such as stream bank setbacks for developing land. Local governments typically conduct planning to meet the sewage disposal needs of the community.

Planning should account for long-range sewer and treatment needs by looking at projections for community growth and development. Comprehensive land use planning, where available, is an excellent tool that can help those assessing the sewage disposal needs of a community or group of communities. In

highly populated areas, regional solutions involving several communities have proven to be a cost-effective means to solve sewage disposal problems.

8.5.3 Past and Ongoing Water Resources Evaluation

IDEM maintains six fixed station monitoring sites in the SJRW that are sampled monthly for various constituents. IDEM executes a probabilistic monitoring design in one of nine major river basins each year. The SJRW is part of the Great Lakes system, and was monitored in 2000, 2005 and 2010⁵². The SJRW will be monitored through the probabilistic program in 2018 as part of the Great Lakes Basin.

IDEM also performs fish tissue monitoring, which monitors about a fifth of the state each year. The SJRW was monitored as part of the Great Lakes Basin in 2015 and will be monitored for fish tissue again in 2020.

All NPDES-permitted wastewater treatment facilities are required to routinely sample their effluent as a condition of their permits. Monitoring parameters and frequencies vary and are dictated by individual permit requirements according to pollutants of concern, plant design flow, and other considerations. In many cases, entities are also required to collect ambient water quality samples upstream and downstream of their discharge location to provide data regarding potential effects on stream water quality. NPDES-permitted dischargers are required to report their self-monitoring results to IDEM monthly as a condition of their permits.

Early communications should take place between IDEM and any potential collaborators to discuss research interests and objectives. Areas of overlap should be identified, and ways to make all parties' research efforts more efficient should be discussed. Ultimately, important questions can be addressed by working collectively and through pooling resources, knowledge, and data.

8.5.4 Adaptive Management

An adaptive management approach allows for changes in the management strategy if environmental indicators suggest that the strategy is inadequate or ineffective. Adaptive management is recognized as a viable strategy for managing natural resources (Baydack et al. 1999). If chemical water quality does not show improvement or waterbodies are still not attaining WQS after the improvement strategy has been carried out, a TMDL revision would be initiated. IDEM would initiate the revision if no other parties wish to do so.

As part of an adaptive management approach, monitoring will be key component of the implementation efforts in the SJRW. Ambient monitoring provides the data used to assess progress towards achieving needed load reductions and meeting water quality standards. BMP effectiveness monitoring provides information that determines if planned activities are, in fact, being implemented and if management practices are performing as expected. Together, information from both monitoring components guide actual plan implementation through each phase using adaptive management.

Under adaptive management, the SJRW implementation efforts should use an iterative approach; one that continues while better data are collected, results analyzed, and the watershed plan enhanced. In this way, implementation activities can focus on a cumulative reduction in loadings under a plan that is flexible enough to allow for refinement, reflects the current state of knowledge about the system, and is able to incorporate new, innovative techniques.

Progress towards implementing planned activities and the performance of installed management measures will be evaluated through BMP effectiveness monitoring. Data collected as part this effort is typically

⁵² Previous probabilistic monitoring design was a fifth of the state each year, but this was revised in 2010, starting in 2011 to do a ninth of the state each year

qualitative information, which tracks both direct (e.g., acres managed under stewardship programs, miles of stream with adequate riparian buffers) and indirect (e.g., number of outreach events, mailed self-assessment survey of properties adjacent to surface waters of the SJRW, partner organization field inventories) activities.

It is recommended that BMP effectiveness monitoring address annual implementation (i.e., installed this year), cumulative implementation, and cumulative implementation with an adjustment for practices that have exceeded their expected lifespan. These totals should be compared with implementation targets and full implementation potential to indicate progress over time.

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